TO ESTABLISH AN ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION AND A NUCLEAR ENERGY COMMISSION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON REORGANIZATION, RESEARCH, AND INTERNATIONAL ORGANIZATIONS

OF THE

COMMITTEE ON GOVERNMENT OPERATIONS UNITED STATES SENATE

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ON

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TO ESTABLISH AN ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION AND A NUCLEAR ENERGY COMMISSION

TUESDAY, DECEMBER 4, 1973

U.S. SENATE,
SUBCOMMITTEE ON REORGANIZATION, RESEARCH,
AND INTERNATIONAL ORGANIZATIONS,
COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:05 a.m., in room 1318, Dirksen Senate Office Building, Senator Abraham Ribicoff (chairman of the subcommittee) presiding.

Present: Senators Ribicoff, Jackson, Nunn, Javits, and Percy.

Also Present. Robert Wager, staff director and general counsel; Paul Hoff, legislative counsel; and Susan S. Geoghegan, chief clerk.

Senator RIBICOFF. The committee will be in order. A copy of the bill, S. 2744, without objection, will be inserted in the record. [See appendix, p. 273, for the text of S. 2744.[1]]

OPENING STATEMENT OF THE CHAIRMAN

Senator RIBICOFF. I ask unanimous consent that the full statement be placed in the record as if read, and I have a very short opening statement. These hearings begin on a note of uncertainty and confusion being heard throughout the land. They begin at a time when the American people want to be assured that the Federal Government can devise the necessary means to deal with the energy shortage on both the near-term and the long-term basis. If they are ever to sever the lines of dependence on foreign energy sources we must create a scientific and technological operation greater than this country has ever known. The natural resources are within reach in this country. What we lack today are the means to convert them into power enough to drive our country efficiently and cleanly into the 21st century.

The energy crisis has been coming for years and yet we have refused to diminish our addiction to foreign oil. If we are to reverse this trend we must mount a massive program of technology to overcome America's lag. Today, less than 5 percent of the total Federal research and development funding is in the energy field. We must develop new ways like liquefaction and gasification of coal to increase our energy supply. At the same time we must cut back on the demand side of the energy equation by promoting new conservation techniques.

Although much of the new agency's work would be done in its own laboratories much will also be contracted out to private industry.

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[1] Additional hearings were held on S. 2744 and S. 2135 on February 26 and 27, and March 12 and 13. Those hearings will be printed in a separate volume.

This raises several problems as well as opportunities. To what extent, for example, will ERDA be cast in the role of creating new industries not just new technologies? Who will protect the consumer as to the price he will have to pay for the new fuels that will make the United States energy self-sufficient? How should ERDA be structured to assure that it seeks out and supports the garage type inventor as well as the multimillion dollar corporations? These are some of the questions which these hearings seek to answer.

The energy crisis is upon us not as suddenly as many would believe but with an impact that few can deny. Our purpose is to move constructively and fast in setting up the research, development and regulatory program to make the United States self-sufficient in energy and to keep our economy strong.

[Senator Ribicoff's prepared statement in full follows:]

PREPARED STATEMENT OF HON. ABE RIBICOFF, U.S. SENATOR FROM THE STATE OF CONNECTICUT

These hearings on S. 2744, establishing an Energy Research and Development Administration (ERDA) and a Nuclear Energy Commission (NEC), begin on a note of uncertainty and confusion being heard throughout the Nation.

They begin at a time when the American people want to be assured that the Federal government can devise the necessary means to deal with the energy shortage on both a near term and a long term basis.

Several approaches are being pursued vigorously by Congress and the Administration to avert serious dislocations of the Nation's economy and way of life.

The Senate already has passed S. 2589, the National Energy Emergency Act, introduced by Senator Jackson, to provide the emergency powers needed to assure that the immediate impact of the energy shortage is fairly distributed and kept to an absolute minimum.

Later this week, this subcommittee will begin hearings on a bill introduced by Senator Jackson, of which I was principal cosponsor, seeking to establish a new energy super-agency—a Federal Energy Administration (FEA)—to assist the President in exercising these powers and to provide the first coordinated, centralized approach to developing a national energy strategy.

This subcommittee already has held three days of hearings on S. 2135, a bill to establish a Department of Energy and Natural Resources.

And, today, we begin hearings on a bill, which I introduced with nine cosponsors, to establish ERDA as the technological means to permit our Nation to become self-sufficient in energy supply.

If we are ever to sever the lines of dependence on foreign energy sources, we must create a scientific and technological operation greater than this country has ever known. The natural resources are already within reach. What we lack today are the means to convert them into power enough to drive our country efficiently and cleanly into the 21st century.

The current energy shortage has come as a surprise to many Americans, but in reality an energy crunch has been coming for many years. Our country contains only 6 percent of the world's population, but consumes over 30 percent of the world's energy. Every day we use 17.3 million barrels of petroleum products. Nearly a third of this total, 6 million barrels, is imported, with the likely prospect of even greater reliance on foreign production in the future.

If we are to reverse this trend, we must act immediately to tool up for the job. Surely we must correct the serious technological situation in which we now find ourselves—namely one in which less than only 5 percent of total Federal R. & D. funding is in the energy field.

The establishment of ERDA, with a proposed R. & D. budget of $2 billion-a-year, is the remedy offered by this bill. Its mission would be to develop technologies for efficiently using fossil and nuclear fuels and other energy sources to permit the United States to produce all the energy its citizens need without having to look abroad.

In my recent report to the Government Operations Committee, "Petropolitics and the American Energy Shortage," I stressed the importance of establishing a national strategy of self-sufficiency—a strategy based on conservation as well as

development and consumption of energy—to combat the use of foreign oil and gas as a political weapon.

ERDA's mission will be to promote the new technologies that will make us less and less dependent on imports of foreign fuels. Liquefaction and gasification of coal, and the development of a safe, efficient breeder reactor, should be high on the list of priorities, based on the present availability of technological and natural resources.

ERDA's broad charter to develop research and development relating to all foreseeable energy sources would permit us also to move forward in extracting oil from shale and sands, harnessing solar and geothermal energy, even the winds and the tides. In addition to increasing energy supply, the agency would research and develop ways of cutting back on the demand side of the energy equation by promoting new conservation techniques. It also would be structured to build environmental and safety factors into all new energy technologies.

The ERDA proposal was drafted in cooperation with the administration. Its concept is bold and its mission laudable in terms of seeking to come to grips with our technological deficiencies in the energy field. But there are several details relating to organization and authority in the ERDA bill which must be discussed and reviewed. These hearings will air those issues thoroughly to assure that ERDA will be designed to carry out its mission effectively, cooperatively, and with full accountability.

For example, the structural backbone of ERDA would be the national laboratories of the Atomic Energy Commission, which would be transferred to the new agency. Are there sufficient safeguards built into the bill to assure that the large proportion of existing AEC personnel and resources would not dominate the nonnuclear elements of ERDA?

Would public health and safety be better served if the regulatory authority remaining with the renamed Nuclear Energy Commission be extended to fast breeder and other nuclear reactors operated exclusively in ERDA's own in-house R. & D. program? The present bill extends this authority only to reactors involved in ERDA R. & D. projects that are operated as part of the power generating facilities of an electric utility.

Although much of ERDA's work would be done in its own laboratories, much will also be contracted out to private industry. This raises several problems, as well as opportunities. For example, what guidelines should be established for determining which R. & D. work should be done where? To what extent, for example, will ERDA be cast in the role of creating new industries, not just new technologies? To what extent should the Federal Government protect these industries from foreign competition, especially in the form of price-slashed oil and gas which would destroy the market for costly, U.S.-developed synthetic fuels. Who will protect the consumer as to the price he will have to pay for the fuels that will make the United States energy self-sufficient? How should guidelines be established for dividing the dollars between short and long term projects; between research and demonstration efforts?

How should ERDA be structured to assure that it seeks out and supports the garage-type inventor, as well as the multimillion corporation?

In general, to what extent should R. & D. guidelines be spelled out by Congress in the ERDA bill and to what extent should the new agency be permitted the flexibility of broad discretionary power?

And finally, would ERDA be most effective in carrying out the Nation's energy policy as an independent agency, as in the present bill, or as a part of the Interior Department or a new Department of Energy and Natural Resources (DENR)?

I believe all of these issues can be effectively raised and resolved in considering the ERDA proposal as a separate bill, rather than in its original form as a part of the DENR bill. It is in the national interest to proceed with ERDA now so that no time is lost in establishing our technological response to the energy crisis. The same holds true for proceeding with the bill to establish the FEA, which also is closely related to the statutory plan for reorganizing our natural resource and energy programs, as originally contained in S. 2135. I shall make every effort to enact the ERDA and FEA bills in the closing weeks of this session.

The energy crisis is upon us, not as suddenly as many would believe, but with an impact that few can deny. Our purpose is to move constructively and fast in setting up the research, development and regulatory programs to make the United States self-sufficient in energy and to keep our economy strong.

Senator Ribicoff. Senator Jackson, who is a member of the subcommittee and also chairman of the Interior Committee, has a state-

ment and before he makes it I want to acknowledge the outstanding leadership that Senator Jackson has shown over many years. I don't think there is a man in this Nation who has had a better understanding of what this country was facing and what must be done, and I tip my hat to you, Senator Jackson, for your outstanding leadership in this entire field.

OPENING STATEMENT OF SENATOR JACKSON

Senator JACKSON. Thank you, Mr. Chairman. I appreciate your kind remarks and I am deeply grateful to you for the vigor and the energy that you are putting into the various proposals relating to the management of the energy problem. I am most grateful for that leadership.

Mr. Chairman, I ask unanimous consent that my entire statement—I want to make some comments—be placed in the record.

Senator RIBICOFF. Without objection, so ordered.

(Senator Jackson's prepared statement in full follows:)

PREPARED STATEMENT OF HON. HENRY M. JACKSON, U.S. SENATOR FROM THE STATE OF WASHINGTON

Mr. Chairman, S. 2744, the measure we are considering today, is a companion bill to a measure which was prepared in the House Committee on Government Operations. I understand that it was developed in consultation with the administration.

I joined you and other Members of this Committee in introducing S. 2744 because I agreed that it should be before the subcommittee for study. I pointed out at that time, however, that I did not fully agree with the objectives of the bill.

I am very much aware of the critical need to put a comprehensive Federal research and development program into effect at the earliest possible time. Since May of 1971, I have chaired the Senate Fuels and Energy Policy Study being conducted under the leadership of the Interior Committee. In nearly every major energy issue which the study has considered, there are at least some research and development factors.

One major reason for our present energy crisis is that the research and development efforts which could have provided us with the technological capabilities we now need so desperately were not undertaken in the past. Fragmented management, overall inadequate funding, and uncoordinated distribution of the meager funds which have been available have all helped to limit our energy alternatives today.

In the United States we now have for the first time very serious absolute shortages of natural gas and petroleum. In the months ahead many regions of the Nation will face critical shortages of heating fuel, gasoline, and other petroleum products.

These shortages are the direct result of the Nation's failure to anticipate energy problems and to develop policies to deal with them. This is especially true in the area of energy research and development. We have failed to move from the realm of theory into the time of commercial demonstration.

Today in the United States adequate resources of domestic fossil fuels and other energy forms are available. The basic scientific theory and some of the laboratory studies necessary to convert the domestic fuels we have in abundance into usable forms of energy exist. But the technologies which would make these domestic energy sources commercially useful within acceptable environmental and economic limits have not been developed.

Until recently, neither industry nor Government has fully appreciated the magnitude of the emerging energy crisis. Even now that the crisis has been recognized, there continues to be a reluctance to undertake the aggressive research effort which is needed.

In March, I introduced, S. 1283, the National Energy Research and Development Policy Act, which would achieve the following purposes:

(1) It would greatly increase the level of funding of nonnuclear research and development.

(2) It would provide Congressionally stated objectives—most importantly the objective to have the option of choosing energy self-sufficiency within ten years.

(3) It would provide guidelines for a comprehensive Federal energy R & D strategy.

(4) It would provide authority to prepare proposals for large-scale joint Federal-industry demonstrations of new energy technologies such as coal gasification and production of syncrude from shale.

This program would be conducted under an interim organizational arrangement which would not disrupt the ongoing research programs of existing agencies and which would not preempt the orderly permanent reorganization of Federal energy agencies.

Meanwhile, I have supported a full-scale reorganization of energy agencies which would provide us with permanent arrangements suitable to administer national energy policies. I believe that a Department of Energy and Natural Resources, which has been proposed by the Administration, is fundamental to a permanent reorganiztion.

The bill which we are considering today, to create an independent Energy R & D Administration (ERDA), cannot serve either of the functions which are needed.

It does not contain the research strategy, objectives, budget goals, and grants of new authority which are so urgently required to get a comprehensive non-nuclear research program underway.

It does not provide an adequate permanent organization which is appropriately related to other Federal responsibilities for energy.

The principal objective of S. 2744 is to isolate the research function from the other aspects of energy policy.

Therefore, although I agree that the provisions of the new measure should be considered, I am reluctant to consider them in isolation from the concerns of overall Federal energy organization.

The measure does not set forth Congressional guidance concerning the strategy, priorities, and objectives for non-nuclear energy research. The technologies which should be considered, the management approaches which are authorized, and the budgetary levels which might be anticipated are all left to the discretion of the Executive Branch.

I know that the Congress has given careful attention to these matters in several Committees. I believe that we will achieve an effective non-nuclear energy research effort more rapidly if the Congress provides some leadership in setting objectives and priorities for the task.

This Committee will soon be considering the President's recent proposal for a Federal Energy Administration which will have important management functions regarding the Nation's energy systems. Many of the functions of that organization will have R & D aspects—the development of coal as a major replacement for oil is only one example. It is not clear how the ERDA would relate to the new Administration.

How would ERDA be coordinated with the extensive continuing energy functions of the Department of the Interior, or of the Department of Energy and Natural Resources if one were later established?

Other provisions of the measure also require detailed examination. A new Nuclear Energy Commission would be created by the bill to undertake the licensing and regulatory functions currently performed by the AEC. The relationship of the new Commission to the nuclear experimental work which will be done by ERDA is an important consideration.

One of the most significant deterrents to public acceptance of nuclear energy has been criticism of the Energy Commission as both developer and regulator of the nuclear energy industry.

This bill would establish an independent Nuclear Energy Commission to carry out the regulatory functions, and I believe that this can be an important improvement in the management of nuclear energy. For the new Commission to be successful, however, it must have a carefully designed mandate, adequate technical support, and, above all, the confidence of the public. I am not sure that S. 2744 provides the mandate and the support, and I do not think hurried enactment of the measure will encourage public confidence.

The relationship of the military program of the AEC to the other duties of ERDA also raises valid questions. The military program is very large in terms of funds, personnel, and activities. It will require a great deal of the attention of the Administrator of ERDA, and it will contribute to a nuclear emphasis in the agency.

There are no easy answers to the management of the military program, but the problem must be given detailed attention.

Perhaps the most important shortcoming of S. 2744 is its preoccupation with the nuclear side of the proposed ERDA. The bill includes quite detailed provisions for the orderly transfer of AEC functions to the new agency. In dealing with the non-nuclear responsibilities of the agency—the area in which existing authority and policy is most inadequate—the bill is cursory at best.

I raise these issues to indicate the complexity of the task before the Committee. I believe that we can resolve them, but we must face them and resolve them rather than ignore them.

Permanent Federal organizations usually have long lives. They should be carefully designed for the long term, not hastily established in the name of expediency. I hope that this Committee will continue to work toward early completion of a permanent energy reorganization package, but I urge the Committee to be thorough and careful in its work.

I intend to assist with that work in every way I can.

Senator JACKSON. I would like to make a few comments just to summarize my prepared statement. I have a committee meeting that I have to Chair, plus a speech on the floor in the next hour, so I regret that I will not be able to stay longer but I will be back to work with you in connection with these hearings.

Mr. Chairman, I have supported a full-scale reorganization of energy agencies which would provide us with permanent arrangements suitable to administer national energy policies. I believe that establishment of a new Department of Energy and Natural Resources, which has been proposed by the administration, is fundamental to a permanent reorganization, and I have introduced legislation along with the chairman to provide for that.

The bill which we are considering today to create an independent energy R. & D. Administration, ERDA, cannot serve either of the functions which are needed. It does not contain the research strategy, objectives, budget goals and grants of new authority which are so urgently required to get a comprehensive nonnuclear research program underway. It does not provide an adequate permanent organization which is appropriately related to other Federal responsibilities for energy.

The principal objective of S. 2744 is to isolate the research function from other aspects of energy policy.

Although I agree that provisions of the new measure should be considered, I am reluctant to consider them in isolation from the concerns of overall energy organization.

CONGRESSIONAL LEADERSHIP

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I know that the Congress has given careful attention to these matters in several committees. I believe that we will achieve an effective nonnuclear energy research effort more rapidly if the Congress provides some leadership in setting objectives and priorities for the task.

FEDERAL ENERGY ADMINISTRATION

This committee will soon be considering the President's recent proposal for a Federal Energy Administration, which, by the way, the chairman and myself will be introducing this afternoon at 1 o'clock.

Senator RIBICOFF. May I add, Senator Jackson, we will interrupt these hearings and start on the FEA organization on Thursday.

Senator JACKSON. And as you know, the FEA will have important management functions regarding the Nation's energy systems. Many of the functions of that organization will have R. & D. aspects—the development of coal as a major replacement for oil is only one example. It is not clear how the ERDA would relate to the new administration.

Moreover, it is not clear how ERDA would be coordinated with the extensive continuing energy functions of the Department of the Interior or of the Department of Energy and Natural Resources, if one is later established.

NUCLEAR ENERGY COMMISSION

Other provisions of the measure also require detailed examination. A new Nuclear Energy Commission would be created by the bill to undertake the licensing and regulatory functions currently performed by the AEC. The relationship of the new Commission to the nuclear energy research work which will be done by ERDA is an important consideration.

One of the most significant deterrents to public acceptance of nuclear energy has been criticism of the Atomic Energy Commission as both developer and regulator of the nuclear energy industry.

This bill would establish an independent Nuclear Energy Commission to carry out the regulatory function. And I believe this can be an important improvement in the management of nuclear energy.

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DEFECT OF S. 2744

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Mr. Chairman, I raise these issues to indicate the complexity of the task before the committee. I believe we can resolve them, but we must face them and resolve them rather than ignore them.

Permanent Federal organizations usually have long lives. They would be, they should be carefully designed for the long term, not hastily established in the name of expediency. I hope that this committee will continue to work toward early completion of a permanent energy reorganization package but urge the committee to be thorough and careful in its work.

I want to assure the chairman, and I know that he is going to be thorough and careful, of my full support in an effort to bring out the best possible legislation.

Senator RIBICOFF. Thank you, Senator Jackson.

May I make a comment to you, Senator Jackson, and to you, Mr. Ash. I, too, believe we are setting up an agency that will be with us for many, many years, and it is important to make sure that this agency is properly structured. At the same time, I personally am convinced that we must move fast. There are differences of opinion, as indicated by the statement of Senator Jackson, who is expert in this field, and frankly, you are going to have to deal with Senator Jackson for many, many more years as chairman of the Interior Committee that will have substantive jurisdiction of what we do, it would be my hope, Mr. Ash, that your staff, Senator Jackson's staff, and the staff of this committee can work hard and long and continuously to the end that we can resolve basic differences. This is no time for petty quarreling. This is no time for pride of authorship, but this is time for constructive cooperation between the executive and legislative branches. I am willing to devote my time and energy to this end and, I am sure Senator Jackson and his staff and you and your staff feel likewise, Mr. Ash.

Senator Javits, do you have an opening statement.

OPENING STATEMENT OF SENATOR JAVITS

Senator JAVITS. Mr. Chairman, I am pleased to participate in the opening of these important hearings as we consider the deepening energy crisis and the serious effects it can have upon our Nation's welfare.

While we must and will take prompt short term action designed to meet immediate problems, there is no doubt that a substantial new effort to make the United States, as far as practicable, self-sufficient in adequate energy supplies must now be undertaken. An energy research and development program must bring together all of the nonmilitary energy research activities of the Federal Government such as those in the AEC, NASA, the Department of the Interior and the National Science Foundation.

During the last 10 years, U.S. demand for petroleum has expanded to the extraordinary sum of over 17 million barrels a day—and this amounts to only half of our total energy needs. Of every 10 barrels of petroleum, about half is used for transportation purposes; and nearly four of these five barrels are consumed by highway vehicles. Homeowners, electric utilities and industry use the other half of our petroleum resources.

Consumption has continued to grow and shortages and higher prices of natural gas or low-sulfur coal, accelerated by air-pollution control

laws, has forced users to substitute residual fuel and distillate fuels, both of which are derived from crude oil. Even without the Middle East crisis, we would have experienced by now a shortage of at the very least 500,000 barrels per day or 3 percent of consumption, due to expanding demands in the United States. But with the uncertainties deriving from the Middle East oil embargo, it is currently estimated that we face a shortage of 2 to 3 million barrels per day, or between 12 percent and 18 percent of our daily requirement. It is impossible to tell how long the shortage brought about by the Arab States will last. Regardless of this factor, we must begin to develop the potential to meet our own energy needs without major—in the United States it is part decisive now—dependence on foreign sources.

We must now put together the organization, the funding, and the brainpower to accomplish this. New sources of energy in such areas as coal, oil shale, solar, geothermal, nuclear fusion, and others must be developed. ERDA and NEC must also examine ways to improve the efficiency of existing power sources designed and used in homes, office buildings, automobiles, and in our industrial processess. Improving this efficiency and reducing the amount of energy now used in every sector of our economy must be long-term objectives of a better energy policy. Getting on top of our energy crisis will take an extraordinary commitment at the Federal level. Developing new resources will have to be done by integrating these policies with those which relate to the preservation of our environment.

Expansion of energy supply is a long-range undertaking, and there are substantial uncertainties as to where our R. & D. effort may lead us. Nevertheless the creation of these new organizational structures of ERDA and NEC will provide the necessary first step in developing more rational policy in the energy area.

Senator Ribicoff. Senator Percy.

OPENING STATEMENT OF SENATOR PERCY

Senator Percy. Mr. Chairman, this week we will be conducting back-to-back hearings on two extremely important bills. In so doing, the subcommittee is being responsive to the President's urgent request for immediate organizational action to help deal with the very seroius energy situation confronting our Nation.

Although our hearings on these two bills are being held in the same week, I think it is important that the two proposals remain separate and distinct. Each should be considered in its own context and judged on its own merits.

ERDA-NEC

The first bill to be considered this week is S. 2744, which would establish an Energy Research and Development Administration, ERDA, and a Nuclear Energy Administration, NEC. ERDA's mission would be to develop technologies for efficiently using fossil, nuclear, and advanced energy sources, such as solar, geothermal, oil shale, and hydrogen, in a manner consistent with sound environmental and safety practices. The NEC would continue the regulatory mission of the present AEC, to insure the protection of the public and the environment against the potential hazards inherent in the use of nuclear materials.

As we examine the ERDA proposal, it is important to bear in mind that another energy R. & D. bill, S. 1283, has already been reported by the Committee on Interior and Insular Affairs. S. 1283 is expected to pass the Senate within the next 2 weeks. We should carefully consider the ERDA proposal in the context of S. 1283 to determine how the two bills complement or conflict with one another.

Also as we consider ERDA, we should carefully examine the relationships between nuclear and fossil fuel research, between military and civilian nuclear applications, between energy needs and environmental protection, between energy requirements, and the protection of human health and safety. These are all important relationships. Energy research, as important as it is in today's world of shortages, must not become so paramount that it endangers human life or habitat.

These hearings should also focus on the relationships between ERDA and the other energy agencies, existing and proposed. We began this year determined to reduce and consolidate the scattered elements of energy-related functions throughout the Government. We have succeeded only in proliferating them further. We now have ERDA, NEC, DENR, EPO, FEA, AEC, NSF, FPC, EPA, Interior, Treasury, Commerce, and OMB, all involved in energy policy, and I have probably left out quite a few.

The second major bill we will be considering this week is the administration's proposal for a Federal Energy Administration, FEA. The FEA would be an independent executive Agency responsible for carrying out operational functions in the immediate energy emergency.

During the 2-year life of the FEA, the Administrator would be the President's adviser on all aspects of energy policies, both foreign and domestic, including the production, conservation, allocation, and control of fuels. This would be an exceptionally powerful position. If the FEA bill is enacted, the President's nominee for Administrator should be examined with great care before being confirmed by the Senate.

I regret that this new Agency must be established on such an emergency basis. It deserves much more careful consideration. Its decisions will touch the lives of every American. I consider this an interim measure, which should be followed as quickly as possible by a comprehensive, thoroughly considered bill which will integrate it with our natural resources agencies into a broader new Department of Energy and Natural Resources.

I regret also that the FEA is already being created by Executive order, based on the thinnest legal underpinnings. These hearings should clearly establish whether a new agency is truly necessary to perform the energy emergency fuctions and whether there is any statutory basis for creating the Agency by Executive order in advance of the legislation.

In any case, the urgency of the fuel shortage situation requires that the Congress act promptly to resolve these questions. If the Federal Energy Administration is to be created, it should be given a sound statutory footing and clearly defined authorities. Transfers of functions from other agencies should be accomplished in accordance with well-established traditions of congressional oversight. Finally, FEA should be regarded only as a temporary step, so that we do not

lose sight of the need for broader reform and consolidation through DENR.

Thank you, Mr. Chairman.

Senator RIBICOFF. Mr. Ash, please proceed.

TESTIMONY OF ROY L. ASH, DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET; DR. DIXY LEE RAY, CHAIRMAN, ATOMIC ENERGY COMMISSION; W. O. DOUB, COMMISSIONER, AEC; JOHN SAWHILL, ASSOCIATE DIRECTOR, OMB; FRANK ZARB, ASSISTANT DIRECTOR, OMB; AND CHARLES BINGMAN, DEPUTY ASSISTANT DIRECTOR, OMB

Mr. ASH. Thank you, Mr. Chairman. I have a prepared statement which I will submit for the record and merely provide some summary comments. First, I would like to introduce the panel that you have before you to answer any questions that the committee may have.

Chairman Dixy Lee Ray at my right, and Mr. Doub, a member of the Atomic Energy Commission on her right.

On my left, John Sawhill, Associate Director of OMB, and to his left Frank Zarb, Assistant Director of OMB.

We certainly appreciate the attention and priority being given by yourself, Mr. Chairman, Senator Jackson, and this committee to the matters of energy. They are very important at this time and the administration is also giving first attention to dealing with the present energy problems.

We have been, as you know, working closely with yourself, Senator Jackson, and respective staffs, and do hope that out of this will come something that will deal with the urgent problems that we have in front of us.

Today, as we focus on S. 2744, we believe that we must particularly view this as urgent action even though it deals with our energy requirements for longer term rather than immediate term action. You have indicated your desire to take up the Federal Energy Administration legislation here on Thursday and, of course, that deals with more immediate problems, and we appreciate that as well.

ERDA-NEC PROPOSALS

The basic rationale behind the ERDA-NEC reorganization proposals is, as we see it, first, to develop our energy technologies and develop them at a sound but fast rate. To do this, as you know, the President has proposed a $10 billion 5-year research and development program specifically to deal with our energy requirements. Then, of course, if we are going to move with this amount of concentrated effort and attention we must organize clearly and precisely to get this job done.

We all know that the Manhattan and the Apollo projects didn't just happen. They themselves were planned for and the organizational structure was worked through carefully and put into place, so we could get on with those tasks.

It is essential that we organize now, not later. We need our structure in place first. Technological breakthroughs require years of leadtime, they require careful preparation and to achieve the goal of self-sufficiency by 1980 we must take major steps starting now.

ERDA PROPOSAL

The ERDA proposal does contemplate the transfer of a number of functions into the Energy Research and Development Administration but those transfers are only the beginning, only the base. On top of that we must augment the capabilities that will be transferred into ERDA by new ones that will be authorized by the bill and, particularly, ones that will enable us to get at nonnuclear energy resources. This, of course, is a key part of the proposal for ERDA.

REGULATORY FUNCTIONS

The Nuclear Energy Commission will then take over the regulatory functions now carried out by the AEC and will also have an increasingly important job to do as we bring more and more nuclear plants on line and encounter a greater need to make sure that the public interest is fully protected by the functions that will be performed within the Nuclear Energy Commission.

So I think, in summary, I would say that now is the time to make sure that we organize the Federal resources in the best possible manner to solve our energy technology problems and to get at them immediately, with concentrated effort and attention so that we can truly achieve the goals that all of us want for this Nation.

We realize that much work lies ahead and we will work very carefully with you and your committee to make sure we contribute all we can to the matter of the bill now before you and throughout its full deliberate consideration. Thank you, Mr. Chairman.

[Mr. Ash's statement in full follows:]

Prepared Statement of Roy L. Ash, Director, Office of Management and Budget

Mr. Chairman and members of the Committee:

I am pleased to appear before the Committee today to present the Administration's views on S. 2744, a bill that would create a new Energy Research and Development Administration (ERDA) and an independent Nuclear Energy Commission (NEC).

As you know, Mr. Chairman, the President is taking several bold organizational steps aimed at dealing with the current energy shortage and at achieving energy self-sufficiency in the years ahead. First, as part of his program to help the Nation through the present crisis, he is taking immediate steps to establish by administrative action a new Federal Energy Administration which will provide an emergency capability for allocating and conserving existing fuel supplies on a national basis. At the same time, we are working closely with this Committee and other members of Congress to provide a legislative basis for this new agency.

Secondly, as part of his program for avoiding such crises in the future, the President has proposed the creation of the Energy Research and Development Administration to manage a greatly expanded and accelerated energy R&D effort. On November 7, 1973, the President urged that Congress give priority attention to ERDA so as to enact that agency during this session of the 93d Congress.

On behalf of the President, I want to express appreciation for the swift and expert manner in which you have responded to his request for priority attention to ERDA. The result of these endeavors is a bill that represent a sound and much-needed reorganization and which this Administration vigorously supports.

Before discussing ERDA and NEC in detail, we should note that S. 2744 is based on an earlier Presidential proposal, transmitted on June 29, 1973, and subsequently introduced as S. 2135, a bill which this Committee has worked on diligently. In addition to establishing ERDA and NEC, S. 2135 would have also created a Cabinet-level Department of Energy and Natural Resources (DENR) designed to bring together related programs now scattered in five departments and two agencies. As such, S. 2135 represented a comprehensive approach to

dealing with problems facing the Nation in the critical energy and natural resources areas.

It became evident, however, that the comprehensive nature of the proposal was leading to prolonged consideration in both the House and the Senate—a prospect worthy of the bill's importance but unacceptable because of the urgency of its energy elements. For that reason, the President requested that ERDA and the closely allied NEC be acted on separately from DENR and ahead of any other organizational initiatives. We wish to emphasize, however, that the need for DENR has not diminished, and that DENR continues to be strongly supported by this Administration. Therefore, we urge that legislation creating this soundly conceived department be enacted as soon as possible in the second session of the 93d Congress.

Let us now turn to the current business at hand—the creation of a strong energy R. & D. agency and how it will meet the national need for an expanded and upgraded R. & D. capability to achieve energy self-sufficiency; and, an independent nuclear energy regulatory commission to carry out the licensing and other regulatory functions now vested in the AEC.

THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Mr. Chairman, the current energy emergency is due primarily to the sudden curtailment of oil from the Mideast. It serves, however, as a painful reminder that the Nation has passed the point at which our energy needs can be met from reliable and readily available supplies, and that continuation of past trends toward growing dependence on other nations for energy supplies is unacceptable.

For that reason, the President has set a national goal for the end of the decade of developing the potential to meet our own energy needs without depending on foreign sources. This endeavor, aptly called "Project Independence," looks beyond the immediate energy emergency and focuses on the underlying problem of expanding and improving our domestic sources of energy while striving to achieve more realistic levels of energy demand. Essential to reaching this goal will be the achievement of significant advances in the state of our energy technology so that the Nation's abundant energy resources can be tapped to produce an adequate supply of clean energy at reasonable costs. The problem is not a lack of basic energy resources, for we have half the world's coal, huge resources of oil shale, vast amounts of oil, including resources in the continental shelf, and some of the finest technical and scientific minds on earth. The problem is "getting at" those resources in ways that are economically competitive and environmentally acceptable. At the same time, better techniques must be developed to reduce the amount of energy presently consumed by our automobiles, homes, power plants, office buildings, and industrial processes. In short, we must advance the state of our energy technology. Accordingly, the President has proposed:

(1) A five-year, $10 billion Federal program to accelerate and expand the national research and development efforts leading to new and improved energy technology; and

(2) An independent Energy Research and Development Administration to provide unified leadership and strong direction for managing this massive energy R&D program.

The five-year, $10 billion R&D program will provide the necessary funds for exploring and developing many promising sources of energy in such areas as coal, oil shale, solar, geothermal, nuclear breeders, nuclear fusion, and others. The program will also strive to develop ways of improving the efficiency of automotive power systems, heating and cooling systems, and other energy consuming mechanisms. The specifics of this program are now being developed and proposals for Fiscal Year 1975 will soon be presented to the Congress.

More than money, however, is needed to achieve prompt and productive results. Absolutely essential are unified direction, concentration of technical and scientific skills, and a strong management framework for carrying out this large-scale R&D effort on a priority basis. In short, we must bring together into a new agency the Federal resources and skills now scattered among several agencies and organize them in the best possible manner to assure vigorous pursuit of our energy goals. Toward that end, ERDA will be created by bringing together important energy programs now operating in the Atomic Energy Commission, Department of the Interior, Environmental Protection Agency, and the National Science Foundation. These resources will then be supplemented as the agency accelerates and expands its activities to fulfill its broad-based energy R&D mandate.

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From AEC will come such programs as:
(1) Nuclear power reactor development,
(2) Controlled thermonuclear research,
(3) Non-nuclear R&D,
(4) Nuclear materials production,
(5) Physical, biomedical and environmental research,
(6) National security programs,
(7) Other non-regulatory activities.
From the Department of the Interior will come the:
(1) Office of Coal Research,
(2) Energy research centers and the synthane pilot plant of the Bureau of Mines,
(3) Underground electrical power tansmission R&D.
From the Environmental Protection Agency:
(1) Development of stationary source emissions technology for fossil fuels,
(2) Development of alternative automotive power systems.
And, from the National Science Foundation: Solar and geothermal energy development.

When these programs were first established, they were appropriately located in their present agencies. Now, however, with the creation of ERDA as a comprehensive energy R&D agency, these energy R&D programs clearly should be brought together in ERDA where they will operate under unified leadership, benefit from the concentration of ERDA's scientific and technical capabilities, and serve as the base for swift expansion of Federal R&D efforts into all promising energy technologies.

On the basis of these transfers, ERDA will have a gross outlay level of approximately $3 billion with a complement of about 6,700 government personnel in FY 1974. Also transferred would be about 85,000 contractor personnel who operate the AEC's extensive and sophisticated research and production facilities valued at about $9 billion. Later, as the full extent of the expanded R&D program is reached, ERDA is expected to increase in size substantially.

ERDA's greatest single asset will be the scientific and technical personnel of the AEC, Interior, and other agencies who will accompany their functions to the new agency. Their proven technological skills, resourcefulness, and experience—combined in the same agency under integrated policy and direction—will enable ERDA to begin accomplishing its mission swiftly and effectively.

If ERDA is to put these impressive resources to prompt and productive use, it must have the best organizational and management framework we can devise. We propose that ERDA be headed by a single Administrator and Deputy Administrator, both appointed by the President and confirmed by the Senate. These officials would be supported by a strong management team consisting of five Assistant Administrators, a General Counsel, and several additional officers.

The five Assistant Administrators would also be appointed by the President and confirmed by the Senate. They will be responsible for line program management and will provide strong leadership and clear-cut accountability for achievement of assigned objectives in the following areas:
(1) Fossil Energy Development,
(2) Nuclear Energy Development,
(3) Research and Advanced Energy Systems,
(4) Environment, Safety and Conservation,
(5) National Security.

Additional management flexibility and strength would be afforded by a pool of not more than seven management positions at Executive Level V. ERDA's Administrator will appoint career officials to these positions and assign responsibilities in such areas as heads of major staff offices or as deputy assistant administrators.

The Assistant Administrator for Fossil Energy Development would be responsible for projects such as coal liquefaction, coal gasification, gas and oil systems, and advanced research on combustion systems and mining technology. ERDA will place significant new emphasis on development of energy from fossil fuels, since that area offers particular promise for near-term relief for the energy shortage.

The Assistant Administrator for Nuclear Energy Development will assure continued emphasis on nuclear R&D and production activities such as fission reactors, nuclear breeders, controlled thermonuclear research, naval reactors, space nuclear systems, reactor safety research, and uranium enrichment.

The Assistant Administrator for Research and Advanced Energy Systems would be responsible for research in the physical sciences, the development of

geothermal and solar energy systems, various energy conservation techniques such as automotive power systems, energy transmission and storage capacities and other advanced energy systems such as magnetohydrodynamics.

The Assistant Administrator for Environment, Safety, and Conservation would carry out critically important programs of biomedical and environmental research; improvements in radiological waste management and transportation; energy-efficient systems research; and ERDA-wide safety oversight. These activities will be closely coordinated with those of the fossil, nuclear, and advanced energy areas, which will also have responsibilities for safety, environmental, and conservation matters as an integral part of developing their respective energy source technologies.

The Assistant Administrator for National Security would be responsible for ERDA's national security programs including nuclear weapons development, testing and production; international security affairs; and the production of reactor materials such as plutonium and tritium. These functions will be carried out by ERDA under the same conditions of security and in essentially the same manner as is now the case in the AEC.

A fundamental management concept of the ERDA approach is to provide flexibility for utilizing a variety of technical and management capabilities, such as industrial contractors, government operated laboratories, private research institutions, and universities. In this manner, ERDA's managers will have adequate freedom of action for getting the job done without building up excessive physical plant or government staff. This approach also develops a close working relationship with industry which will later help ensure a smooth and speedy transition of developed technology to broad commercial application.

The bill also contains a number of administrative provisions which are necessary for enabling the Administrator to manage the agency effectively and with a reasonable degree of flexibility. The basic structure of ERDA is designed to meet current needs as now perceived. Undoubtedly, adjustments will be needed as R. & D. problems change and as ERDA gains experience.

THE NUCLEAR ENERGY COMMISSION

The Nuclear Energy Commission will carry on the AEC's present licensing and other regulatory activities. The change in the Commission's title from "Atomic" to "Nuclear" will more accurately describe the technical matters of concern to the Commission.

After more than two decades of Federal nurturing, the nuclear power industry is reaching maturity. Currently, the 37 nuclear power plants licensed for operation constitute about 5% of the electrical capacity of this Nation. By 1980, nuclear power plants are forecast to be providing about 20% of our total electric power capacity. By 1990, it is expected that nuclear power will be over 40% of the electrical capacity, and by the year 2000, as much as 60%. Moreover, the supporting nuclear fuel cycle activities, such as waste disposal, will expand and accelerate to keep pace with this growth. Medical and industrial uses of radioisotopes are increasing as well. All of these activities must be controlled by licensing and other regulatory procedures to insure the public safety.

The proposed Nuclear Energy Commission will provide the full-scale independent regulatory commission that is warranted and required for the adequate regulation of the rapidly growing nuclear industry. And, in view of the increasing impact of nuclear regulatory decisions on the energy supply and environmental quality of the Nation, it is more important than ever to separate nuclear development from nuclear regulation activities and thereby remove even the appearance of a conflict in the AEC's regulatory decisions.

The Nuclear Energy Commission will assume the AEC's present licensing and related regulatory responsibilities for assuring that the civilian uses of nuclear materials are consistent with public health and safety, environmental protection, and the antitrust laws. These functions encompass standards, setting, technical safety reviews, environmental evaluations, public proceedings, licensing, inspections and enforcement, and materials safeguards—all of which have broad impact on the public as well as the regulated industries.

Under the President's proposal, AEC's five-member commission form of organization would be retained for the NEC as the best means of assuring continued fair and impartial regulation of commercial nuclear power. In addition to the five-member commission itself, NEC will include AEC's present regulatory staff, offices and other resources that perform licensing, regulatory and related safety and environmental activities.

Spared the burdensome demands of a large, complex energy R&D and production operation, NEC's commissioners and officers will be able to concentrate

exclusively on regulatory tasks. A five-member commission with the sole function of regulating nuclear energy will also upgrade and help expedite the NEC's regulatory processes.

The Atomic Energy Commission's transition to an exclusively regulatory agency will be vastly simplified by the evolutionary steps which have already been taken over the past decade to organize its regulatory functions into a separate, integrated operation under a Director of Regulation. As a result, the NEC can be brought into existence with a minimum of change and disruption.

Functions to be performed in NEC include those now administered by the Director of Regulation, the General Counsel's staff for Regulation, the Adivsory Committee on Reactor Safeguards and the licensing and appeal boards. The Nuclear Energy Commission will also have overall planning, funding, and evaluation authority over the $51 million Light Water Reactor Safety Program. In the areas of biomedical and environmental research and waste management and transportation, it is expected that NEC will be provided additional funding (up to $5–$10 million in NEC's first budget) to undertake research for insuring the protection of public health and safety.

Resources now associated with the AEC's licensing and regulatory functions include approximately $98 million in 1974 Budget outlays and about 1,550 full-time permanent employees. In support of these functions, additional resources needed to create and maintain a high level of technical competence in NEC will be sought as soon as possible.

The line organization proposed for NEC would be comprised of four directorates reporting to an Executive Director of Operations. Each directorate would be responsible for a major regulatory function as follows:

(1) Standards setting for nuclear reactors

(2) Licensing of nuclear facilities and materials

(3) Inspection of nuclear facilities and activities and enforcement of NEC's regulations

(4) Confirmatory assessment research on safety, safeguards, and environmental concerns.

The Directorates of Standards, Licensing, and Inspection and Enforcement (now Directorate of Regulatory Operations) currently exist in the AEC and will be transferred intact to NEC. The new Directorate of Confirmatory Assessment will provide NEC with an independent capability for developing and analyzing technical information related to reactor safety, safeguards, and environmental protection—a capability essential for assuring effective and objective decision-making.

In addition, NEC will have the authority and resources to have regulatory related research completed where it is deemed necessary by the Commission in determining the adequacy of safety factors related to nuclear reactor design and operation.

In order to insure the safety of future nuclear power plant technologies, NEC will license ERDA's nuclear reactor demonstration facilities involving electric power generation components and thus require the same rigid regulations and procedures for ERDA as are currently established for commercial nuclear reactor power plants. In addition, NEC would license new storage facilities for high level radioactive waste resulting from processing and utilization of nuclear materials.

Mr. Chairman, in conclusion, I must stress again that big energy problems lie ahead of us and we must organize our Federal resources in the best manner possible to maximize our ability to solve these problems swiftly. ERDA will bring to the accelerating and expanding energy R&D program the concentration of skills and resources, balanced R&D approach, and strong management structure that are essential to the successful conduct of an undertaking of this size and complexity.

At the same time, NEC will carry out the AEC's crucially important regulatory responsibility in a framework free of nuclear development responsibilities and with leadership able to focus exclusively on regulating the growing nuclear industry.

We believe these agencies are vitally needed and we pledge every assistance in working with this Committee and its able staff to create ERDA and NEC without delay.

Nuclear Energy Commission

The separation of regulatory functions from the research, development and production activities of the present Atomic Energy Commission is another step in the evolution of the Federal Government's involvement in nuclear energy. The five member AEC Commission, including its staff offices and Licensing Boards

plus the three regulatory Directorates under the Director of Regulation will form the nucleus of the renamed Nuclear Energy Commission (NEC). NEC will be an independent regulatory commission responsible for licensing the civilian use of nuclear power and materials.

BACKGROUND

Significant Federal involvement in nuclear energy began with the formation of the Manhattan Engineer District in 1942, and AEC was established in 1946. The first commercial uses of nuclear materials were authorized by the Atomic Energy Act of 1954, at which time the AEC established a comprehensive system of licensing. As the role of the AEC expanded from research and development into regulation of the use of nuclear production and utilization facilities, the need for a separate regulator staff was evident. In 1961, a new Director of Regulation was established reporting directly to the Commission.

The nuclear power industry has matured rapidly since this organizational change and the growth is continuing with the number of licenses issued for nuclear reactors currently doubling every two or three years. By 1980, 20–30% of electrical energy will be generated by nuclear reactors.

Maturity of the nuclear power industry requires a full-fledged regulatory agency free of development responsibilities in order to handle this ever-increasing workload in an impartial manner to assure the public health and safety.

ORGANIZATIONAL CONCEPT

NEC's mission will be to insure the protection of the public and the environment from potential health and safety hazards inherent in the use of nuclear materials.

The five member Commission will continue to carry out, but on a full-time basis, the regulatory functions of the present AEC which include:

(1) Policy setting and assessment,
(2) Oversight of regulatory operations,
(3) Adjudication of licensing and related cases,
(4) Resource allocation.

The Chairman (Executive Level II) and four commissioners (Executive Level III) will be appointed by the President and confirmed by the Senate.

Regulatory responsibilities of the NEC encompass the licensing of all nuclear utilization and production facilities .for industrial or commercial purposes including the transportation, disposal, import or export of these materials. Licenses are issued for such diverse uses as nuclear power generating plants, chemical separation plants, nuclear research facilities, and radioisotopes used in medical therapy.

The Commission will be supported by NEC staff resources which will include:

(1) A General Counsel to provide legal advice and assistance.
(2) A Controller to manage financial program.
(3) A Secretary and Public Affairs Officer to assist in the conduct of Commission business.
(4) A Policy Analysis Office to conduct broad policy planning analysis and assessment and operational planning and control functions.

In addition, the Commission will continue to be assisted by the licensing and advisory boards of the AEC, which will continue to report to the Commission. These include:

1 Atomic Safety and Licensing Board—to conduct public hearings and issue decisions of licensing.
2 Atomic Safety and Licensing Appeals Board—to conduct reviews of initial decisions and perform other appellate functions.
3 Advisory Committee on Reactor Safeguards—to review and advise the Commission on safety standards and facility license applications.

The line organization proposed by the Administration for NEC would be comprised of four directorates reporting to an Executive Director of Operations (Executive Level V) who will be appointed by the Commission. He would have responsibilities for direction and coordination of major program elements as delegated by the Commission with each Directorate responsible for a major regulatory function as follows: (refer to the attached NEC organization chart).

(1) Standards setting for nuclear reactors.
(2) Licensing of nuclear facilities and materials.
(3) Inspection of nuclear facilities and activities and enforcement of NEC's regulations.

(4) Confirmatory assessment research on safety, safeguards, and environmental concerns.

The Directorates of Standards, Licensing, and Inspection and Enforcement (now Directorate of Regulatory Operations) currently exist under the AEC's Director of Regulation and will be left intact in NEC. The new Directorate of Confirmatory Assessment will provide NEC with an independent capability for developing and analyzing technical information related to reactor safety, safeguards, and environmental protection that is required to assure effectiveness and objectivity in its standards, licensing, inspection and enforcement activities. Under NEC direction, such technical information and analytical methods will be developed in an organizational medium free of developmental bias. These independent data would be in confirmation of, and thus in addition to, data supplied by the proponents of the systems for which licenses are sought or other regulatory action requested. In addition, this Directorate will provide the Commission the capability to identify alternative technological approaches leading to improved reactor safety, safeguards, and environmental protection.

The basic structure outlined above for the organization of NEC is designed to meet current needs as we now perceive them. It is possible that adjustments in the structure will be needed as the number and complexity of regulated activities and facilities increase and as we gain experience with the organization. The legislation provides flexibility to permit future changes when the need for them becomes clear.

In order to maintain a high level of competence of the regulatory staff and to provide the broadest possible range of technical information, NEC will have the statutory authority to provide budgetary support for related research in reactor safety, and the biomedical and environmental sciences, or it may contract for such research from independent sources.

LIGHT WATER REACTOR SAFETY CONCERNS

Critics of AEC have raised questions whether there has been adequate protection of public health and safety of the Light Water Reactor now in commercial use. The AEC has undertaken extensive safety research of the Light Water Reactor at facilities in Idaho. The $51 million capital program is principally centered around the Loss of Fluid Test Facility (LOFT) and Power Burst Facility (PBF).

To insure that this priority safety research program adequately responds to known safety problems, NEC will have overall planning, funding, and evaluation authority of the Light Water Reactor Safety Program. ERDA will continue to perform the day-to-day management of the program on a reimbursable basis.

In addition, in the areas of biomedical and environmental research and waste management and transportation, it is expected that NEC will be provided additional funding (up to $5–10 million in NEC's first budget) to initiate such research in these general areas as required to insure the necessary resources for the protection of public health and safety.

NEC and the Advisory Committee on Reactor Safeguards will continue the AEC's present regulatory practice of conducting safety reviews of ERDA nuclear activities and facilities at the request of the ERDA Administrator and will participate in the review required by the National Environmental Protection Act of ERDA's environmental impact statements on nuclear programs.

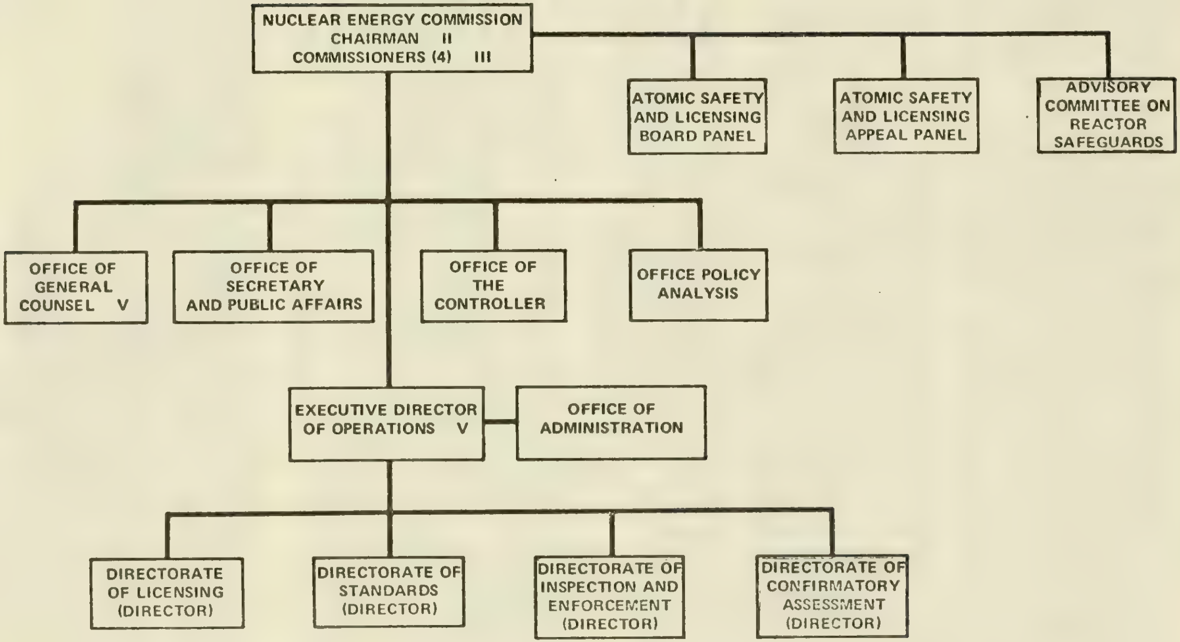
REGULATORY AUTHORITIES ON NEW GENERATIONS OF NUCLEAR REACTORS

In order to insure the safety of future ERDA developed nuclear reactor power generating plant technologies, NEC will license these demonstration facilities. This will include the full provisions of Sec. 103 and Sec. 182 of the AEC Act of 1954 and means that ERDA will be required to meet the same rigid licensing regulations and procedures currently established for commercial nuclear reactor power plants before construction of a demonstration plant. As an example, the Liquid Metal Fast Breeder Reactor demonstration plant, which involves an electric power system component, will be required to obtain a NEC permit prior to construction. In addition, NEC would license high level radioactive waste storage facilities.

To summarize, the Nuclear Energy Commission is designed to insure the safety of nuclear power plants and related facilities, to eliminate the potential for regulatory and developmental conflicts, to eliminate the risk of subordinating regulatory to developmental functions, to maximize regulatory objectivity and impartiality, to increase public confidence, to permit the Commissioners to concentrate exclusively on regulatory issues, and to become the fully independent regulatory agency which the rapidly maturing nuclear industry requires.

PROPOSED

NUCLEAR ENERGY COMMISSION



NOVEMBER 1973

The Energy Research and Development Agency

A massive federally sponsored R&D effort has been proposed by the President, providing for the expenditure of $10 billion over the next five years, in order to develop energy technologies to meet the Nation's energy needs. A new independent agency is needed to provide the proper organizational framework, management and technical expertise to achieve the Nation's R&D goals in the energy area. Short term energy needs will mainly be fulfilled by relying on presently developed forms of energy. Longer range energy requirements can be satisfied only through more efficient use of present energy sources, development of new energy sources, and better conservation and utilization practices. The President is therefore proposing the establishment of an Energy Research and Development Administration (ERDA).

ERDA's mission will be to develop technologies for efficiently using fossil, nuclear and advanced energy sources to meet growing needs and in a manner consistent with sound environmental and safety practices. ERDA will have a broad R&D charter covering the development of technologies for all foreseeable energy sources and utilization systems. The agency will have responsibility for policy formulation, strategy development, planning, management, conduct of the energy R&D and for working with industry to assure that promising new technologies can be developed and applied. In addition, ERDA will continue the weapons production and development programs of the AEC.

ERDA will be formed by transfer of AEC's energy R & D, military applications, basic research, production, biomedical and environmental programs, Interior's Office of Coal Research and Bureau of Mines energy centers, NSF solar and geothermal energy development activities and portions of EPA's stationary source emissions control technology and alternative automotive power systems (AAPS) research programs. Exhibit A contains estimates of FY 74 program resources involved in the proposed transfers.

Advantages of ERDA are:

1. ERDA will be built upon the substantial scientific and technical base of the present Atomic Energy Commission and will make use of the technical management capabilities of that agency.
2. ERDA will provide a central agency for the conduct of most Federal energy R & D programs. ERDA will have a broad charter to conduct research and development on the full spectrum of our energy resources and utilization processes covering extraction, conversion, transmission and utilization technologies.
3. ERDA will be so organized and managed that fossil fuel, advanced energy sources and conservation will receive full recognition and priority along with nuclear energy R & D functions.
4. ERDA will work closely with EPO, DENR, NEC and other agencies in carrying out its mission.

Organization Concept

The ERDA's organization will be headed by a single Administrator and a Deputy Administrator, who will be appointed by the President with the advice and consent of the Senate and be principally concerned with setting R & D policy, external agency relationships and overall direction of the agency. There will also be a General Counsel appointed by the Administrator.

The proposed agency line organization is a balanced structure of five Assistant Administrators, each being responsible for a major program area, as follows: (Refer to the attached ERDA organization chart.)

(1) Fossil Energy Development,
(2) Nuclear Energy Development,
(3) Research and Advanced Energy Systems,
(4) Environment, Safety and Conservation,
(5) National Security Affairs.

The Assistant Administrators will be appointed by the President and confirmed by the Senate.

An additional pool of not more than seven management positions at Executive Level V are proposed. The ERDA Administrator will appoint career officials to these positions and assign responsibilities. Possible uses include: heads of major staff offices, as deputy assistant administrators or other assignments.

The three Assistant Administrators for fossil, nuclear and advanced energy systems will plan and execute programs designed to develop technology by energy source. The objective will be to exploit major existing sources of energy and to explore new and advanced ways of producing energy, including consideration of, and research on, closely associated environmental, economic, safety, and con-

servation considerations. One advantage of organizing on the basis of energy sources is that it provides within an agency a means for assuring balance and meaningful priorty setting among the competing energy sources.

Significant emphasis will be placed on fossil fuels; e.g., coal gasification, liquefaction, and clean combustion systems devices, etc., since this area appears to be the most promising, based on current resource reserves and research technologies. Over $50 million of the President's FY 1974 funding increase for energy research is for coal research to devise methods to convert coal into gas or liquids and to develop control technologies to reduce its air pollution characteristics when used directly.

Continued emphasis will be placed on nuclear energy development. Present programs to develop and demonstrate the commercial feasibility of breeder reactors will be continued. The breeder generates more nuclear fuels than is consumed in the process and this improves the efficient use of a valuable energy resource. This is an advantage over present commercial reactors. A major long term program on Controlled Thermonuclear Reactors (fusion) will be continued because of its tremendous clean energy potential. A major activity will also involve operation of the extensive government owned uranium enrichment operation to provide the domestic and much of the free world's supply of nuclear fuels. The program to transfer this to the private sector will continue to be emphasized. A high level of attention will be devoted to safety considerations in all nuclear activities.

Advanced energy technologies will aim at utilizing energy source and utilization technologies such as geothermal, solar, winds, tides, advanced power cycles, automotive power systems, as well as providing a framework for exploring new concepts and ideas that evolve over time. A number of these have significant potential if economical and safe technologies can be developed. This area will also conduct basic physical research in energy related areas.

Environmental protection and safety activities are integral to each of the major energy development organization functions. However, because of the overriding importance of these aspects of energy use, a separate organization element will be provided to support R&D on biomedical and environmental effects associated with various energy systems and energy waste management as well as help assure that appropriate environmental and safety R&D and related considerations are addressed more broadly and comprehensively. Conservation R&D efforts will also be carried out within this major function and will include conducting general research concerned with slowing the rate of growth in demand. Each major program area will also be charged with assuring that the energy systems developed meet requisite environmental, safety, and conservation standards.

The remaining major organization area, National Security, will have responsibility for performing the AEC's military applications and reactor materials production programs. These functions will be carried out by ERDA under the same conditions of security and in much the same manner as is now the case in the AEC.

The basic structure outlined above for the organization of ERDA is designed to meet current needs as we now perceive them. Undoubtedly, adjustments in the structure will be needed as R&D problems change and as we gain experience with the organization. The legislation should provide flexibility to permit future changes when the need for them becomes clear.

ERDA's top management will review the alternative concepts and set program priorities among alternative technologies. The line Assistant Administrators will sponsor their technologies in this process. The ERDA Administrator and Deputy Administrator will be supported by a strong and independent analytic staff to provide assessments on developing technologies. ERDA R&D decisions will form an important input to the Administration in setting priorities and developing energy strategies.

The ERDA headquarters structure is designed to tap the AEC expertise in technical areas as well as in contract management and related skills. The existing AEC field organization will not be changed significantly in structure. Six energy labs from the Bureau of Mines involving about 700 career personnel will be affilitated with the current national laboratory structure. ERDA programs in fossil fuel R&D and advanced energy systems must be able to utilize existing AEC capability for physical, biomedical and environmental R&D as well as contract and other management support functions. Some use of the present nuclear capability to work on fossil fuel, advanced energy systems and conservation will

probably be necessary and desirable. To the extent practicable, existing capital plant, fixed overhead and administrative overhead will be utilized.

A great deal of flexibility will be provided to the Administrator in carrying out the programs. Existing AEC and Bureau of Mines labs, outside contractors, universities, and private research institutions can be used to carry out the elements of the programs in achieving objectives.

The ERDA approach to developing safe, efficient energy sources will involve the energy industry to the maximum extent possible and will supplement existing and planned R&D by private industry. Once technology has been developed to assess its feasibility, industry will have to take the lead in further development and in apply it on a commercial scale. Therefore, ERDA's strategy will be to encourage independent energy R&D by working closely with industry in the development of technology to facilitate a rapid, smooth transfer. In this regard, jointly funded Federal and private projects will be encouraged.

CONCERNS ABOUT AEC DOMINANCE IN THE PROPOSED ERDA

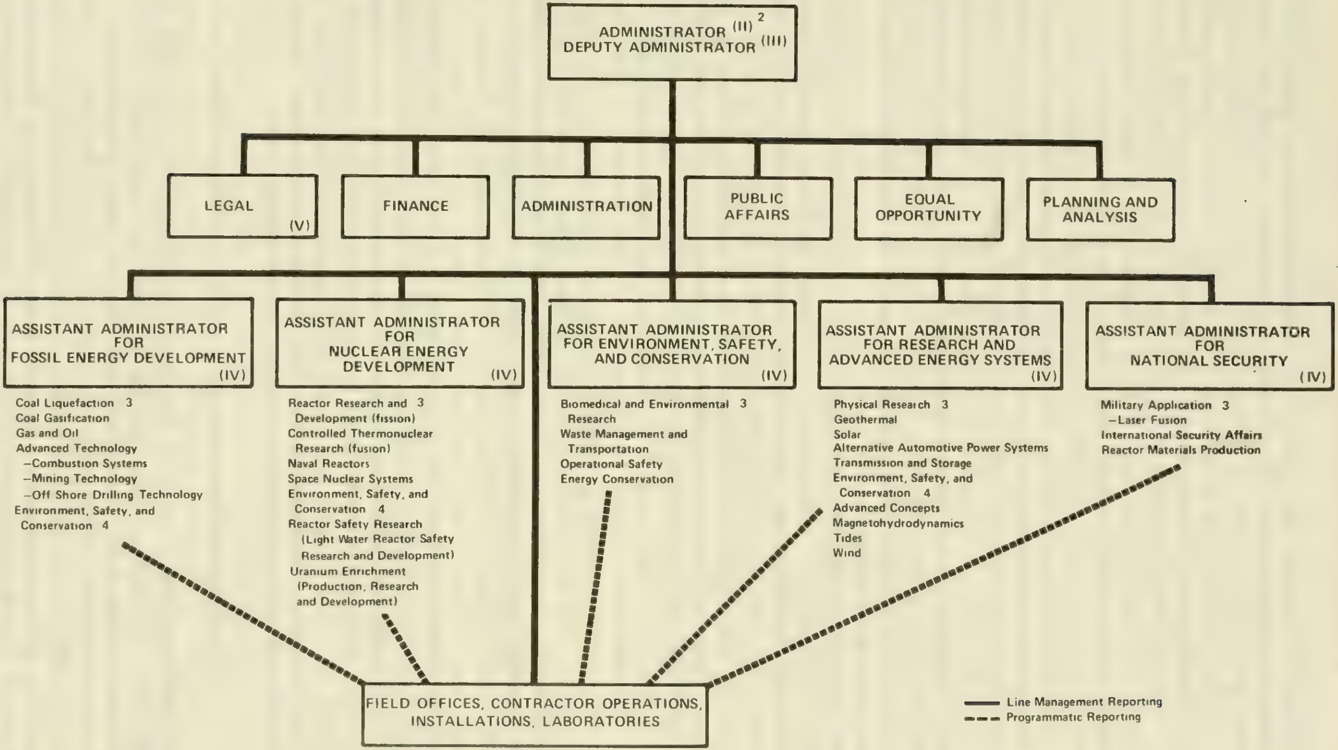
One major concern of the coal industry as well as some members of Congress is that the existing AEC personnel and resources, might dominate other important elements of ERDA. However, special consideration haw been given to this concern to assure that balance is achieved in developing technologies to meet energy needs. The more significant ERDA design features that will help to assure balance are:

1. The proposed ERDA organization is a significant departure from the AEC structure. There is a single Administrator, as compared to a Commission-General Management arrangement.
2. The top tier of ERDA is carefully designed to achieve balance among major energy sources—fossil, nuclear and advanced. Environmental, safety and conservation elements are also given a significant role along with the major ongoing responsibilities for military applications.
3. The President has stated that a significant amount of R&D funding will be for fossil fuels, especially coal and other energy sources. This will serve to balance the present nuclear imbalance in Federal energy R&D funding and overcome the nuclear dominance concern.
4. The Administrator will be directly supported by a number of key high caliber analytic staff offices which will assist in neutralizing the energy source advocacy of the major program areas in assessing the merits of the various technologies and balancing resources among competing areas.
5. Existing regulatory responsibilities of the AEC will remain behind and become the Nuclear Energy Commission, a renamed independent regulatory agency.

What major programs will ERDA undertake over the next five years and at what approximate funding levels?

The President has proposed a Federal energy research and development effort of $10 billion over a five-year period. He has also directed that an additional $115 million in fiscal year 1974 be devoted to the acceleration of certain existing projects and the initiation of new projects. About one-half of the funding for the new initiatives for fiscal year 1974 are devoted to coal research and development, with emphasis on producing clean liquid fuels from coal, improving mining techniques to increase coal mining safety and productivity, accelerating the coal gasification program and developing improved combustion systems. The AEC in consultation with Interior and other agencies is to make recommendations by December 1, for energy R&D which should be included in the FY 1975 budget.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION [1]



[1] The General Advisory Committee, Military Liaison Committee and the Patent Compensation Board of the AEC are proposed for transfer to the ERDA.

[2] Roman numerals indicate Executive Level of position

[3] Proposed areas of interest

[4] Integral to development of energy technologies. Not duplicative of the Assistant Administrator for Environment, Safety and Conservation.

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GOVERNMENT-INDUSTRY R. & D. PARTICIPATION

Senator Ribicoff. Mr. Ash, the administration proposes ERDA as a long-range operation. The President proposes $10 billion. Senator Jackson talks in figures of $20 billion. There is a basic question: What is the Federal role in solving the energy problem? Is it just the job of the Federal Government? What role does private industry play? How will we coordinate and divide the responsibility between the Federal Government and private industry in the development of alternate sources of energy and research and development?

Mr. Ash. Mr. Chairman, we have some good examples before us that we draw from, but that we needn't necessarily be limited to, and those examples deal with the tremendous amounts of research and development that lie behind our defense programs and our space programs. In each case the Federal agencies created to carry out those projects, including the important research and development elements, had within the agency certain R. & D. capabilities but nevertheless looked to the private sector which has so much more such capability to carry out main roles itself.

Now, in this particular case there is one difference. In addition to ERDA working with business to harness its great capabilities for research and development, the end results of this research and development will not merely be military weapons or space projects; the end results will feed back into industry itself. So what we must be sure to do is to find those techniques by which, on the one hand, we can harness the capabilities of the private sector and, on the other hand, make sure the end results are fed back into the private sector in a way that best serves the interests of the total people of this country; that is, we must make sure we don't, on the one hand, unjustly enrich private groups that will be involved by providing them research results of value without compensation in one form or other. On the other hand, we must make sure, and this is very difficult, that those results truly are transmitted into the private sector so that they can be truly put to work.

That is easier said than done and it may be just as big a problem as getting the research and development work done in the first place, but I would expect ERDA to begin to establish some very strong relationships with a broad base of private industry, learn some of the problems that they have, some of the opportunities that they see, and also certainly harness one of the great assets of this country—its private sector capability for research and development.

STRANGLEHOLD ON NEW IDEAS AND ALTERNATIVES

Senator Ribicoff. I am just curious, for many years, and with some justification, the major oil companies and the automobile industry have been accused of throttling new ideas, new alternatives, new methods concerning automobile mileage, the use of alternative sources of energy, and it is felt that there is a backlog of inventions and methods within the automobile companies in Detroit and the research facilities of the oil companies which would be helpful. How do we unlock the automobile companies and the oil companies methods and inventions which would be helpful at the present time?

Mr. Ash. Well, to the extent that those facts do exist, and I guess none of us knows exactly to what extent they do exist, but there

certainly has been discussion of it, we would clearly expect one of the major objectives of an ERDA would be to get at those possibilities by equipping itself with enough capability to judge the feasibilities of a research effort of a particular kind, and then going in the direction that would truly pay off. That is, I think, something that we can't overlook.

We cannot build an ERDA just as a contracting agency dealing only with financial and contractual arrangements. We must at the same time build a substantial R. & D. capability so that it has an understanding and an appreciation, and an ability to fully evaluate the research and development efforts that have gone on and results that have been reached elsewhere. It must determine those ways that will bring them through the ERDA organization into the light of day and into real life. We must build that kind of capability on the ERDA organization itself.

Senator RIBICOFF. Your Department, or your Office, has great capability. I would hope that you would set some of your staff to work at the Patents Office to go into the patents issued to automobile companies and oil companies the past two decades to find out what patents have been issued to them which would be most helpful in the present crisis, and which have not been reduced and made available to the American public. My feeling is that you will find a number of inventions that could really start being used at once and save you a lot of time in independent research and development on what is already within the purview and knowledge of our technology.

Mr. ASH. I am sure that is a very good idea and we will pick it up and certainly make sure it happens.

INCENTIVES FOR PRIVATE SECTOR INVOLVEMENT

Senator RIBICOFF. What economic incentives do you have in mind to get the private sector moving more rapidly in this field. What do you think is necessary for the private sector?

Mr. ASH. Well, of course, we know how the private sector operates and what it responds to and what, in our society, it should respond to—the opportunity to do more business and make a greater profit or return on its investments by being innovative. Clearly, we want to harness that motive force because we have shown that that works well in the kinds of a society that we have.

I think we have to ask ERDA to be innovative in this field. As I indicated before, in the major areas where the private and public sectors have worked together in research and development, there has been one major difference. The end product either went off to the moon or was a military product. ERDA's products largely will be plowed back into the economic mainstream via commercial applications.

I don't think that we know all of the answers here, but the kind of an answer that is already being applied is one where we can contract, in effect, for a turnkey result from industry that includes a major R. & D. effort. For instance, we don't fully know all the technology dealing with shale and the recovery of oil from shale, but it is quite conceivable that, in the leases that would be signed with the private sector on Federal lands that contain such shale, that we could build right into the lease structure itself a strong motivation for that private company, that lessee, to do a massive amount of research and de-

velopment not only in its own self-interest but in the self-interests of all the people of the country, but it could be built right into the contractual arrangement.

I don't suggest that is the only thing. In fact, what we must do is be innovative in determining how we can harness together the great resources of the Federal Government and the private sector toward the ends that we all want.

TAX SYSTEM FAVORS OIL COMPANIES

Senator RIBICOFF. Mr. Ash, our tax system has been used for many, many years for economic and social ends. Governor Love last week before the Finance Committee said that he contemplated it would take an investment of about $1 trillion in capital to develop alternate sources of energy.

My own independent research indicates, and I don't know what the figures are today, but up to a few months ago, that in the Persian Gulf countries it takes about 6 cents a barrel of oil from exploration to placement on the tanker.

The same barrel of oil costs about $2.88 to explore and produce in the United States.

Now, when you consider the differential in cost between 6 cents and $2.88 you have a fantastic gap. Yet American oil companies receive from our tax laws foreign tax credits, intangible drilling expenses, and oil depletion allowances amounting to billions of dollars to encourage them to explore and produce in countries that embargo their shipments to the United States.

Should we be encouraging American oil companies through our tax laws to invest their capital and technology in countries that embargo the production of oil produced by American knowledge and capital as against encouraging those same companies, through our tax laws, from developing, exploring, and producing all energy, all alternate sources of energy, in the United States?

Mr. ASH. As you know, Mr. Chairman, the President's tax reform proposals, submitted now many months earlier, did contain within them a major provision dealing with the very point that you mention; that is, the limitation on the ability of American oil companies to deduct as an expense the oil exploration work done overseas. That has been before the Congress for a number of months now. I am sure that given the current situation that we could look again and see what other possibilities there are not only domestically with necessary economic inducements to justify investment in domestic production, but those steps that would inhibit some of the foreign development.

Now, the tax reform proposals dealt with the latter. They haven't to the stage that dealt with the former.

THREE NEW TAX BILLS INTRODUCED BY RIBICOFF

Senator RIBICOFF. I am going to give the administration an opportunity to back that up. I introduced three bills yesterday in the Senate which deal with these problems. I realize that the administration is talking basically in its proposals of a few months ago of intangible drilling expenses, which are very substantial. If that provision can't come out of the Finance Committee, and I question whether it can,

I will put it on as an amendment to a tax bill. I would hope I would have the administration's support on the floor of the U.S. Senate when we try to put it across.

Mr. Ash. We certainly will consider it.

I would like to make a point, and I suppose its so axiomatic that it hardly needs making. The kind of capital we are talking about necessary for development of our energy resources is large, and most capital still in this country is privately owned to a large extent. It is that capital at least that we have our eyes on. Capital goes to where it is wanted and where it is rewarded, and if it isn't rewarded adequately it just doesn't go to any particular investment. So we need to make sure that as we now seek out the massive amount of private capital for the development of our energy resources, we provide that it has a return commensurate with the risk and commensurate with the alternate uses of that same capital. I think therein lies a great part of our solution.

CAPITAL FOR LONG TERM INVESTMENT

Just this last week I met with the heads of a great number of life insurance companies that were having a convention here in Washington and, of course, the life insurance companies are the repositories of tremendous amounts of this country's long-term capital; that is, capital available for long-term investment. I made a very specific point to them that they should examine the opportunities in energy investment, probably one of the best kinds of investments that they can make, with the kinds of funds that the life insurance companies accumulate. They are giving consideration and, as you may remember, just 2 or 3 years ago, it is more than that now, we felt the need for massive amounts of capital for some of our housing in the less developed regions and in some of the urban areas. The life insurance industry stepped up as an industry, stepped up with commitments, first a billion dollars and then a second billion dollars. Here we are talking about many more billions, and I think that there are pools of capital standing ready, providing the return competes with other returns available for that same amount of capital.

Senator Ribicoff. I have many more questions but we have a large attendance at the committee so we will confine ourselves to the 10-minute rule and then we can come back for additional questions.

Senator Javits.

Senator Javits. Thank you, Mr. Chairman.

ABOUT $2 BILLION A YEAR FOR RESEARCH

Mr. Chairman, I would hope to develop this subject with the witnesses as we get further into it but in the first instance I would like to ask him this: This bill contemplates a commitment of roughly $2 billion a year to research. Such a commitment has to be long term otherwise it is meaningless. We have got to talk about a 10-year swing in this matter and anyone with even elementary business experience knows that and, Mr. Ash, you certainly have had more than elementary experience.

Therefore, a two part question: One, is the administration prepared to commit itself to this expenditure for energy research and, second,

how can we give assurance that we will persevere in this program over a sustained enough period of time to make it worthwhile for the major research brains of this country to participate?

How shall we write it into the legislation so that this is not just a short-term proposition?

MARSHALL PLAN REVISITED

Let me give you an example of what I have in mind if the administration has not already matured its thinking on it. When we wrote the Marshall plan we faced the same problem, and if you will refer back to it you will find that we wrote a section into the Marshall plan saying that we contemplate an expenditure, I believe the sum was $17 billion, and that while one Congress is unable to commit the next, we nonetheless wished it recorded in the legislation that this plan, which is incorporated in the legislation which I think was passed in 1948, is a $17 billion plan. Now, as a matter of fact we never appropriated I think more than $11 or $12, that was all that was needed. But the impact of the fact that the United States was committed to what was then an unbelievable sum of money had a great effect.

Now, if you would be kind enough to give us your views?

Mr. ASH. Senator, I think that the President's statement itself was certainly the beginning of such a commitment to reach out for a 5-year plan and certainly it is possible to think in terms of a longer term. But, it was going quite in that direction by saying that from the President's point of view he recommends a national commitment of $10 billion over the next 5 years just for energy research and development. It was of the same nature as that which you have described about the Marshall plan. He didn't commit other Presidents or certainly didn't commit the Congress at all, but it did set out the scope of this program for a number of years. I am sure that we would very much welcome a congressional response that also perceived the long-term nature as you have described, and that made those kinds of commitments. Even though they don't legally commit future expenditures, they certainly commit a course of action and a state of mind that we would like to have bear on the future decisions, future Presidents, future Congresses.

So I think we are on that track right now. Maybe your suggestion is that 5 years itself may not be long enough to make this commitment, and I would agree with you. In fact, when we talk about energy self-sufficiency or the capability for energy self-sufficiency by 1980, we already have gone beyond the 5-year period there.

So I would certainly subscribe to your point that while we have made a 5-year form of commitment there are still many other 5 years beyond that that this will be a major problem.

AN ADMINISTRATION COMMITMENT NEEDED

Senator JAVITS. Well, Mr. Ash, in view of the fact that we have run into the sharp end of budget cuts and impoundments, I think we ought to have a recommendation or declaration from the administration as to what it wishes to see committed to this particular effort and over what period of time and then we would decide how we could incorporate that in legislation. I really say this not by way of criticism

but because I hope you will agree with me, you really want the top brains of this country to turn to it. You have got to have a Manhattan project approach where we are undertaking a sustained package of activity and we are going to support it and a fellow can really say "OK, I will now divert my energies for x years to this project because it is going to be ongoing, and the next Congress and the next President aren't just going to cut it off."

Now, could you give us in some authoritative way therefore an estimate of amount and time duration so that we then might decide what we wish to crank into this legislation, which would encourage the business concerns and top research brains of the country to really turn to at this time.

Mr. ASH. I think the question is quite well fitted to some work that is going on even now and that may well provide the very answer that you seek.

As you know, I believe, because we have discussed it earlier, just yesterday Miss Ray, Chairman of the AEC, submitted to the President the work that she has been leading now for a number of months aimed at coming up with a comprehensive energy research and development program which, as we will now have further discussions with it, will come before the Congress and possibly provide you with the very sort of proposals that you have in mind when you make that suggestion. I think we are on that very track and will be coming to the Congress very soon with the kind of data that I believe you are asking for.

Senator JAVITS. Could you get it for us in time to be cranked into this bill, Mr. Ash?

Mr. ASH. It depends partly on how fast the bill proceeds and we, of course, encourage you to proceed fast with it.

Our basic goal internally had been to include it in the budget that we are now preparing for fiscal 1975, at least the first year of it, and we are working on that schedule and maybe I should ask either Miss Ray or Mr. Sawhill to comment on what they see the possibilities of timing are and whether it might fit this or not.

A REPORT—"THE NATION'S ENERGY FUTURE"

Dr. RAY. Thank you, Mr. Ash. Senator Javits, during the course of a conversation with the President yesterday afternoon we presented the report to him. May I say that this report has been drawn up in 5 months' time with input from a very large number of people both within the Government and in the private sector. It contains a series of recommendations for a national research and development program in energy. The President received the report with considerable interest and he urged that I make the report available and discuss it with the Congress as early as possible.

Now, in doing the report we were also working in very close cooperation with the energy people in the administration and, particularly, with Mr. Sawhill in the Office of Management and Budget. The President's directive requested not only recommendations for a general 5-year plan for energy R. & D. within a sum of $10 billion, but also specific recommendations for fiscal 1975 increments. These specific recommendations were coordinated with the various agencies involved and it is my understanding that the budget examiners in

Mr. Ash's office are, at the present time, beginning the process of reviewing departmental fiscal 1975 requests, including the recommendations from this report. I would presume the material could move forward very efficiently and very effectively.

Senator JAVITS. So we are talking about a $10 billion program for 5 years and that report purports to prove that is what we need, that is the optimum figure, is that right?

Dr. RAY. No, sir. What we are recommending in this report is the Federal Government's contribution of about $10 billion to a total national energy research and development program which we estimate to be something more than double that.

Senator JAVITS. Something more than $20 billion?

Dr. RAY. Yes, the figure that we recommend $22,500 million. After discussions with many representatives from private industry we have reason to believe that there could be an input from many different programs of private industry up to a total of about $12,500 million.

Senator JAVITS. I thank you very much. And the backup for those figures are in this report which will be available to us? Could it be submitted to the committee?

Dr. RAY. Yes, sir.

Senator RIBICOFF. Without objection, the entire report will go in the record.

[See appendix, p. 309, for Chairman Ray's report to the President.]

Senator RIBICOFF. Senator Javits, before you came in, Senator Jackson was here who raised some questions about the organization, I told Mr. Ash and Senator Jackson that I am sure it is the intention of this committee to work as fast as we could in setting up an organization that could do the job and to that end I assured Mr. Ash that his staff would work with our respective staffs and Senator Jackson's staff to try to clarify and work out any misunderstandings, any differences of opinion, and that we would move as fast as possible for the sake of the Nation on this particular piece of legislation.

Senator Javits. I thank the chairman and I thank the witnesses in front of me.

Senator RIBICOFF. Senator Nunn.

Senator NUNN. I just have a couple of questions for Mr. Ash, Mr. Chairman.

First of all, we have several bills pending, one is S. 1283 by Senator Jackson which passed the Interior Committee last week. This is also S. 2744 a complementary bill dealing to some extent with the same subject. I am not very clear on what the administration's position is on S. 1283, the bill introduced by Senator Jackson. Could you answer that question Mr. Ash?

Mr. ASH. Yes; I will.

S. 1283

We certainly do agree that a central agency and substantial funding is needed to develop technologies, and we believe that the ERDA proposal we have meets that. We do have some concerns about the interim organization that is contemplated by S. 1283, whether that would effectively centralize Federal energy R. & D. as it would be given a role primarily to coordinate other agencies rather than have a tight management authority over the R. & D. functions itself.

It also might create further fragmentation of energy R. & D. just at the time when we believe that we have many needs, many reasons to bring together the kinds of technologies that are elsewhere in the Government that together can be more effective than they can be fragmented.

My understanding is that S. 1283 was introduced because it was believed that it might take too long to get ERDA legislation and this would be an interim measure to fill in the gap. We trust that it would be possible to move ERDA legislation just as fast as S. 1283 and have the structure in place that not only manages R. & D. funding but manages R. & D. itself and gets more closely to the end objective that we all want: A highly concentrated, highly effective research and development organization brought to one place and with one unequivocal authority to deal with the challenges that it has.

Senator Nunn. Are you saying that if ERDA passes that S. 1283 is unnecessary and the administration would not favor it?

Mr. Ash. That is correct.

DIFFERENCES BETWEEN S. 1283 AND S. 2744

Senator Nunn. What do you consider the essential differences, in summary account or fashion, between S. 1283 and this proposal?

Mr. Ash. The main difference is that S. 1283 establishes a resources allocation process rather than establishing an energy R. & D. management process. It sets up a structure to contract with and oversee other agencies engaged in their own work where we believe there is much need at this time to operationally bring together the research and development functions related to energy and to manage research and development rather than manage managers of research and development.

Senator Nunn. I know you already touched on this to some extent but, as I understand Dr. Ray's testimony a moment ago, the overall plans call for spending $10 million by the Federal Government and about $12.5 billion by private enterprise all over the next 5 years, is that essentially the report you just gave?

Dr. Ray. Yes sir. I should emphasize that the report of course is a series of recommendations.

Senator Nunn. Yes.

Dr. Ray. I do not wish to imply that it has been accepted or is ready to be put into effect.

NUCLEAR VERSUS NONNUCLEAR RESEARCH

Senator Nunn. Does this in effect represent a doubling of what the administration felt was necessary as recently as a week or two ago.

Dr. Ray. No sir. I think there are three numbers here to keep in mind, and each needs its proper definition. Before there was any special effort on the whole energy problem; the Federal Government was spending about $800 million a year in energy research and development, largely in the nuclear field. Then the President, earlier this year, stated his belief that we should make a major commitment, particularly to nonnuclear research and development, and that we should do so by creating a Federal program of $10 billion over 5 years, including some nuclear but nevertheless substantially more

nonnuclear research. The President suggested a Federal program with Federal funds of the $10 billion for the 5 years. Now, the research work, the planning work——

Senator NUNN. So that would have been an increase of $1.2 billion over the present program?

Dr. RAY. Per year.

Senator NUNN. Per year, primarily in the nonnuclear field?

Dr. RAY. There would be some continuing increase in nuclear but a substantial portion by far, many times over the amount spent before, in nonnuclear energy R. & D. I want to make this point particularly, that ERDA will no longer be, or be perceived of as a largely nuclear R. & D. organization. Its mission is to emphasize just as much, and give just as much attention, just as much priority, just as many resources to the nonuclear opportunities for energy research and development as to nuclear. So the $10 billion is a Federal funding level for a 5-year period which more than doubles the funding level at which we have been operating on for nuclear only.

COMMITMENTS FROM THE PRIVATE SECTOR

Mr. ASH. Then the third number, and that is the one that has come out of the study that Miss Ray has just reported upon, is the expected commitments of the private sector itself, of private sector funds in doing its own research and development, thus having a total national program, public and private, of course, and way more than just the Federal funds. This is as it should be. We believe that the very nature of what we are talking about here is one that should make substantial usage of private sector funds as well because ultimately we are talking about improving the private sector's capability and service in producing our energy needs.

FUNDING

Senator NUNN. How much of the additional $1.2 billion per year is not funded in the present budget requests?

Mr. ASH. Well, for the fiscal year 1974, the one that we are now in, and with the supplemental that has been presented for this fiscal year, that would bring the total R. & D. funds for this year to $1 billion.

Senator NUNN. But now what about in the original 1974 budget?

Mr. ASH. It was $772 million.

Senator NUNN. Is this less than we were spending earlier?

Mr. ASH. No, it was about that. The $800 million I was using was in fact rounding off that very number.

Senator NUNN. So until the supplemental budget came up, this $1.2 billion was not in any request, is that right?

Mr. ASH. In fact even that doesn't relate to the whole of the $1.2 billion.

Let me make clear about the $1.2 billion. As we talk about $10 billion over 5 years, it is not reasonable to think that we are going to step up immediately from an $800 million a year right to a $2 billion a year rate and run it flat for 5 years. There will be a growth curve built into that so it will rise to a level higher than $2 billion at the end of the 5-year period but fiscal 1975 wouldn't be even as much as $2 billion because it can't be spent effectively. If you step up research and development efforts too steeply, then you are just throwing money at

the problem, and the job here is to manage the rate of increase so that you have the maximum effectiveness of research and development, not just the maximum expenditure.

Senator NUNN. The $12.5 billion figure that you have come up with for private industry, when you add that to the $10 billion that you are anticipating as Federal expenditure over the next 5 years and the total package expenditure is approximately what Senator Jackson's bill has had in it for some time, is it not?

Mr. SAWHILL. Maybe I am not completely familiar with Senator Jackson's bill but I believe that his figure of $20 billion was stretched out over the 10-year period. This contemplates $10 billion for 5 years and I think they were both contemplated from the Federal Government so in a sense they equate each other.

THE $10.5 BILLION FIGURE

Senator NUNN. Two quick questions on the $10.5 billion. The first question is how much of this is already being spent, and how much of of it is new commitment from private enterprise. Secondly, how did you arrive at this figure? It seems to me it would take a tremendous amount of consultation with private industry.

Dr. RAY. Yes, indeed. Such consultation has been taking place. Let me emphasize again that these are estimates, based upon discussions held over a period of the 5 months of this study. We met with representatives from all components of the energy industry. We discussed with them the kinds of things which they said they were interested in and wanted to do. These programs would require, for example, guaranteed price, or a guaranteed market, a small increment of Federal funding or incentives of various sorts that need guaranteed initiative. From this we tried to derive some reasonable estimate of what the probable increment of private funding might be.

Let me give you one example, if I may. There is a good deal of discussion about increasing domestic oil production and we normally think about that in terms of drilling new wells and that is important. But there is another way to increase production and that is secondary and tertiary recovery. Now, secondary methods are already quite well known in the industry and can be used to get more oil pumped out of existing wells. The procedure varies from oil field to oil field because of differences in viscosity and composition of the oil and so on. Many of these procedures are proprietary, but they are shared among different oil companies by virtue of licensing arrangements.

Most fields with primary pumping yield not more than about a third of the oil which is known to be in the ground. In order to get more of that oil out the so-called secondary method is used. It usually consists of various techniques of putting in water under pressure and causing the oil to float up to where it can be pumped more effectively. These techniques can be utilized and will bring another 10 to 20 percent of the total oil out of the ground. But to do this there has to be a fairly large investment of capital equipment at the beginning of the program. As the industrialists say, the funds are loaded at the front end; and given the prices that are available at the present time for domestically produced oil, it has not been economic for the companies to utilize this procedure.

INCENTIVES

With some incentive from the Federal Government the companies would be willing in many cases to use this procedure. Incentives might take the form of a guaranteed price for the secondary oil as compared to the primary or a guaranteed purchase or marketing agreement. With such incentives, companies might be willing to invest in secondary recovery methods.

It is on the basis of these kinds of discussions that we have tried to arrive at estimates of the magnitude of Federal funds needed to make an impact on the energy picture.

May I add one more thing. We also set up a series of workshops that met under the sponsorship of Cornell University. A very small number, 8 or 10, outstanding people in various fields, examined this question of Federal-private industry involvement and tried to help make some estimates about what the increment of funding could be expected from the private industry. This group was headed by Mr. Thomas O. Paine of the General Electric Co. The report from that workshop and preliminary results are included in our report. It has been published in full by Cornell University, and is now available.[1]

Senator NUNN. Chairman Ray, is that $12.5 billion all new money, or does that include some that has already been spent?

Dr. RAY. No, this would be an estimate of the incremental funding from private industry.

Senator NUNN. Incremental?

Dr. RAY. Private spending.

Senator NUNN. Thank you. Mr. Chairman, I have some other questions but I think I have used my time so I will defer.

Senator RIBICOFF. Senator Percy.

GOVERNOR LOVE'S RESIGNATION

Senator PERCY. Dr. Ray and Mr. Ash, we are delighted to have you here this morning. Mr. Ash, I would like to ask you about that part of your title dealing with management rather than budget this morning? Essentially what happened to Governor John Love. When the administration and the White House called me Friday afternoon to tell me about the creation of this new Federal Energy Administration, I asked the question: What about John Love's relationship? He was on this job 5 months and I hoped we were retaining his expertise and the relationship he has developed with Congress. He has had a long training and experience and he gave up the Governorship. I was assured John Love was very much a part of this, he was staying right on. So, I was somewhat shocked to pick up the paper, as I had been after the "Saturday Night Massacre," to find there had been some changes in organization.

What did happen? Why could not John Love have been retained in this picture when we are bringing 250 executives from the oil industry in? We need manpower that understands the energy problem and understands also the ways of Government.

Mr. ASH. I had hoped, and I know the President had hoped, that John Love would continue because Governor Love had made a very

[1] Available in subcommittee files.

significant contribution to the work that has been done in these last few months. He had performed a leadership role under very trying circumstances, as is always the case in the beginning of any project, and had done it so very well.

He chose for reasons of his own to offer his resignation but certainly from the point of view of myself and the President he had done a very good job and we had hoped that he would continue in the work that is to be done ahead.

As you know, having observed it, you see that for the first few months of any program, the task is to deal with the broad policy issues and get them in place, sort them out, determine in which directions to go and in all, Governor Love had worked very effectively and very successfully toward doing so.

Then, with the change of mode, in effect, that comes from the different dimension of the problem than we had, say, 3 months ago, the organization is taking a new turn. It must now be highly operational, and there are now both roles to play, a very highly operational role and a Federal energy proposal that will be considered by this committee Thursday, I understand, particularly where we want to develop the operational role that is added to the policy role that had been done before.

He left for reasons of his own, but certainly it wasn't that either the President or anybody that I know of felt in any way dissatisfied with the very important work he had done in the time that he had done it.

A NEW ENERGY CZAR

Senator PERCY. I think we are always concerned when emergencies and crises require the necessity for a czar in American life. Obviously, we are going to look very carefully at the qualifications of Mr. Simon, in the light of the kind of awesome power and responsibility that he is going to have over the life of every single American. The legislation will require confirmation proceedings, I presume; is that right?

Mr. ASH. Yes, sir.

Senator PERCY. And I presume we will give the most careful thought to his qualifications. You obviously must have been a key factor in recommending that this kind of power be given to the Administrator, to shut down, I presume, businesses, to change working hours, and to change the mode of life of Americans. You must have considered the qualifications of the man who must carry out the responsibilities. I know this is not a confirmation proceeding, but would you care to give us some comment on the competence and capability of Mr. Simon and his background, and why he seemed to be, of all men in the United States, the best man to be selected by the administration for this awesome power over our lives?

Mr. ASH. Well, as you know, for a number of years now, he has, in one way or another, worked closely with the energy and particularly the petroleum part of the energy business, and knows considerably about it, both in national and domestic dimensions. Also in his present work, as anybody who has worked with him knows, when a job needs strong leadership and when that job requires the very kind of involvement in daily operations of industry and people of the country, Bill Simon is certainly a type that can accept that responsibility, provide clear and clean leadership, and that is the kind of leadership that is required. We do need it. It is not one that the Government can deal

in a policy sort of way. It is one in which the Government, unfortunately in many respects, but I guess necessarily, must involve itself in so much of the daily lives of so many industries and so many people. He is quite fitted for that. As you know, he will be here Thursday to testify on the FEA proposal itself, and you will get an opportunity outside of a confirmation hearing to deal with him.

Senator RIBICOFF. I wonder if the Senator will yield at this point on Mr. Simon?

Senator PERCY. On the Chair's time?

MR. SIMON—AN UNCOMMON BUREAUCRAT

Senator RIBICOFF. On the Chair's time. I believe Mr. Simon is the most uncommon bureaucrat that I have ever dealt with in many years in Government. He was in charge of oil policy primarily 5 months prior to Governor Love. He is the only man in Government that you could have called up on the telephone and get an answer immediately. If there was a problem that required him to get the answer from anywhere in the country, you would get that answer immediately.

As an example of how Mr. Simon moves, I believe my colleagues on the committee were not present last Sunday because of other commitments, but once it was evident that Mr. Simon was going to be the President's appointee, having been in session on Sunday, both Senator Jackson and I received a call from Mr. Simon as to whether we would work with him on Sunday to try to get the parameters of this new agency in order, and Senator Jackson and I spent 3 hours with Mr. Simon and his entire staff trying to come to an objective, and a clarification of the problems.

I personally don't believe that the President could have chosen a more able, competent man to handle the problems of being a czar than Mr. Simon.

Now this is not a confirmation hearing, but since the question has been raised from my experience with Mr. Simon I cannot help but take this opportunity to commend him most highly, and I believe the country and the President and the Congress will be very pleased with his actions even though we may not agree with some of his objectives and his decisions. I would gather that we are going to go through a very controversial year in this country concerning decisions that Mr. Simon and the administration and the Congress will reach, but that is how the system works. This is on my time.

Senator PERCY. I think that interjection is an extremely important one, and I agree Bill Simon is a brilliant man. He will have a thorough going over in his confirmation proceeding, no question about that, because it is an unusual emergency situation and the power he would have is tremendous.

Senator RIBICOFF. You will have a chance to ask him on Thursday.

Senator PERCY. We will see him on Thursday, and I did talk to him on the telephone on Saturday, and I think we are grateful for the majority party's confirmation of the judgment of the administration in selecting him.

Mr. ASH. If I may interject, you haven't asked the question, but sitting to my left is the prospective deputy to Mr. Simon, Mr. John Sawhill, and he also comes with the same kind of talents and capabil-

ities. It is like giving up my own right arm to give him up to this function, on the other hand, I am sure that you will find that the leadership of this prospective new agency will be in exceedingly good hands, ones fully able to match the tremendous challenge that they will have.

Senator PERCY. Good.

NEW ENERGY AGENCIES

Mr. Ash, could you tell us, in the 3 years of struggling now in the real world of politics, how far have we strayed from the Ash Council report and the ideal world pictured in that report so far as energy and natural resources organization policy is concerned? Particularly, could you explain the proliferation of energy agencies, existing and proposed, that have been created in the last 3 years? We have a proliferation of them that is quite extensive. Just to list a few of them, we have ERDA, NEC, DENR, EPO, FEA, AEC, NSF, FPC, EPA, Interior, Treasury, Commerce, and OMB. All of them are now involved in energy. Will you take a long look and tell us when we are going to try to stop the proliferation and start consolidating and reducing their number?

Mr. ASH. The Senator may remember about 3 years ago there was proposed what was then called a Department of Natural Resources, which had an energy component in it. DNR served as the model for the proposed Department of Energy and Natural Resources, and we still believe that that is the proper direction to go, to bring the degree of concentration necessary to deal with the subject of energy.

We are proposing moving ERDA at this time as an urgent step that needs to be taken but nevertheless is consistent with ultimately getting to that same concept because we think it was a good one.

Now, on the other hand, the statement that was made, again in one of the President's proposals for organizational change of 3 years ago, didn't anticipate this problem in particular, but said there will always come the time when some problem will arise to such a level of importance that we will create, we must create, a separate agency to deal with it for so long as it does stand out from all others with its special importance.

Here we have come to one such situation. At earlier times we have done the same on other kinds of matters, and I am sure that even had there been DENR we might well have considered the importance of this subject such that we would want to bring close to the President a responsibility and authority to deal with certain aspects of this problem that can be dealt with more strongly right out of the President's office than in any agency.

So the basic model is still in place. We are moving toward it inexorably. Maybe it will take a little longer than we wanted but, at the same time, we recognize there have emerged always some special problems, special challenges that need to be addressed.

In this particular case, you may know this is regarded as so important that the President has made himself the Chairman of the Energy Emergency Action Group so that he can personally participate in the total policy deliberations that bear on the subject of energy.

SAFETY FACTOR OF NUCLEAR POWERPLANTS

Senator PERCY. Doctor Ray, at this time I have just one question for you: The President has proposed sharply reducing the time required for licensing nuclear powerplants from an average of 10 to 6 years. At the same time we know that many citizens groups are aroused and concerned about the safety factor, so much so that the President commented on this on national television.

How can the conflicting needs of society for more energy, and certainly of nonfossil fuels, and safety be reconciled? Also how would the ERDA-NEC split assure the safety of nuclear powerplants?

Dr. RAY. Thank you, Senator. I will try to respond to that very broad question. We believe that nuclear energy provides a very viable alternative to other means of creating electricity, and our projections are that while we are using only about 5 percent of the capacity, that is of the generating of electricity right now from nuclear plants, in the course of the next 10 years that will rise to between 20 and 30 percent, around 40 percent by 1990 and probably better than half, close to 60 percent, by the year 2000.

We believe that there are other sources that also can and should be used and certainly look forward to increasing the use of geothermal power for electric generation where that is possible. Some of the other alternatives are more far reaching, I believe. We don't have technology on hand as yet in an economical way to use solar power for direct conversion to electricity and, of course, nuclear fusion is a hoped for development, given the support of research over the rest of this century into the 21st century.

Now, we recognize that it takes a long time to build a nuclear powerplant, 8 to 10 years from concept to generating electricity, and part of this is due to a very cautious, very careful, and conservative approach to handling a type of power which everyone acknowledges is a very powerful source of energy.

For that reason the nuclear industry is controlled and regulated more drastically than any other segment of our society. The specifications for construction of plants and for the way in which they can be operated are subject to review by the Atomic Energy Commission at every stage along the way from construction to final operation.

We are, at the present time, reviewing our procedures to see whether we can't find some efficiencies there consistent with proper consideration for safety and for environmental impact and, with your permission, I would like to ask Commissioner Doub, whose field of expertise this is, to comment more fully.

But before I let go of this microphone I just want to point out that improving the regulations and licensing and permit rules will not totally solve the question of the long time it takes to build these plants. There are construction delays as well. Now, this type of thing applies to other sorts of powerplants as well as those that become nuclear, because specifications of quality control in nuclear plants are so high, the effect of construction delays are more felt in that field.

But we are hopeful that from the standpoint of the production of raw materials and components and the labor problems involved, all of these things can be reviewed and efficiencies can be found to reduce the total time.

May I ask Commissioner Doub to answer?

Senator PERCY. I think it would be well in consideration of the time limit to turn the questioning over to my colleagues at this time. I appreciate that part of the answer very much, Dr. Ray. We will come back to you, Commissioner Doub, in a few minutes.

I would like to commend the chairman and our ranking Republican on this subcommittee, Senator Javits, for immediately calling these back-to-back hearings on two extremely important bills. I assured Secretary Simon and I assure you, Mr. Ash, that the Congress will certainly cooperate in every respect we can in this situation. We will consider these bills as rapidly as possible, commensurate with our trying to understand and improve them. I think the two proposals should remain, however, separate and distinct and be given due consideration, each of them separately.

Senator RIBICOFF. Thank you very much, Senator Percy.

Commissioner Ray, would I have your permission to ask unanimous consent to allow your statement to go in the record as if read so we can spend the remainder of our time on many questions in our respective minds?

Dr. RAY. Yes, sir, I would be pleased.

Senator RIBICOFF. Without objection the entire statement will go in the record as though read.

[The above referred to statement follows:]

PREPARED STATEMENT OF DR. DIXY LEE RAY, CHAIRMAN OF THE U.S. ATOMIC ENERGY COMMISSION

Last August I had the privilege of testifying before this subcommittee on S. 2135, which contained the administration's original proposal for reorganizing Federal energy research and development efforts. Members of this subcommittee and others in the Congress and the administration were already aware at that time of the need for consolidating and strengthening the Federal structure for energy research and development. Events during the intervening four months have strengthened our conviction that reorganization is necessary. It is, therefore, a pleasure to testify personally and on behalf of the Atomic Energy Commission in support of S. 2744, which is a revision of S. 2135.

The need for immediate reorganization of Federal energy research and development in a single agency was clearly stated in the President's November 7 television address to the Nation. Without such a consolidation it would be extremely difficult to develop to their full potential the variety of fuel sources: fossil, nuclear, solar, geothermal, hydro, and others required to meet our growing energy needs. During the last several months I have had an exceptional opportunity to assess the scope and magnitude of our research and development requirements for all of these energy systems in formulating recommendations to the President for a 5-year, $10-billion program for Federal energy research and development. To realize the potential of our domestic fuels will require a balanced, vigorous, and imaginative use of all our energy sources and improved efficiency in energy systems. The Energy Research and Development Administration proposed in S. 2744 will help to attain the kind of balanced approach that we have sought to establish in our recommendations to the President.

This effort will require us to integrate the activities of diverse research groups which are presently competing for a variety of resources: funds, skilled people, and facilities. If those resources are to be used in the best possible way, there must be central planning and coordination of all energy research and development efforts. The creation of ERDA will help to focus responsibility for the Government's diverse activities in energy research.

In creating ERDA, S. 2744 would provide for a unified and focused Federal research and development program. The functions of the Nuclear Energy Commission (NEC) would assure the AEC's important regulatory responsibilities are continued by an independent agency.

ERDA would be formed by bringing together some of our Nation's best talent in research and development. The Atomic Energy Commission would bring to

the new agency its extensive experience in technical management, a resource that would help launch ERDA quickly. The network of national laboratories created by AEC would provide a valuable technical base for the new agency. ERDA would likewise acquire professional talent in fossil fuel development from the Department of the Interior through the transfer of the Office of Coal Research and the Bureau of Mines Energy Research Centers to ERDA. The new agency would also be enhanced by transfer of solar and geothermal energy development from the National Science Foundation. From the Environmental Protection Agency ERDA would acquire experts on the development of alternative automotive power systems and in developing technology for controlling emissions of air pollutants from stationary sources using fossil fuels.

ERDA ORGANIZATION

To integrate these broad capabilities into an effective organization, ERDA has been structured to:

Assure full recognition of all potential energy systems at the highest organization levels and

Retain flexibility for adjustment to new opportunities and circumstances not now predictable.

Serving at the top levels of the ERDA organization would be:

The Administrator and Deputy Administrator. These two senior officials would be appointed by the President with the advice and consent of the Senate.

Five Assistant Administrators, each responsible for a major area. These Assistant Administrators would also be appointed by the President with the advice and consent of the Senate. They would be chosen for their technical and managerial ability in their respective areas.

Staff offices, reporting to the Administrator, are to supply staff services in such categories as legal services, finance, administration, public affairs, equal opportunity, and planning and analysis.

Field office managers will be responsible for overseeing execution of ERDA programs performed at contractor or Government facilities. Specific responsibilities will vary among the offices.

The Administrator would need the flexibility provided in this legislation to mold this organization in the way that would seem most effectively to accomplish ERDA's program responsibilities.

ERDA would adopt the merit personnel system of the Atomic Energy Commission. This system has proved successful in attracting and retaining highly qualified scientific, technical, and supporting personnel under merit principles.

ADMINISTRATOR AND DEPUTY ADMINISTRATOR

The single Administrator approach focuses responsibility for management in one single office. The Administrator and his Deputy would establish policies and plans and they would coordinate, support, and manage (1) energy research and development programs, (2) production of special nuclear materials, and (3) research, development, testing and production of weapons in accordance with national defense responsibilities.

ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY

A vital component of ERDA would be its programs to develop fossil energy. It is recognized that many of the most promising near term solutions to energy shortages may be found in advancing fossil-energy technologies. The personnel being provided by the Department of the Interior would form the core of talent upon which ERDA would draw. The Assistant Administrator for Fossil Energy would focus on developing new and improved technologies for the economical recovery of coal, oil, and natural gas. Another major concern would be the improved uses of fossil energy sources. Finally, inherent in all of these activities would be the continuing responsibility to protect the health and safety of the public and to improve the efficiency of processes.

Basic to all efforts would be the need to bring fossil fuel concepts to the point of commercial application. This Assistant Administrator would be responsible for facilitating transfer of new technology to industry through appropriate mechanisms.

Developing new and improved technology for the economic recovery of coal, oil, and natural gas includes:

Research on advanced extraction technology relating to energy source materials;

Liquefaction and gasification of coal;

Production of coke from low-grade coals and lignite; and

Transformation of oil shale to petroleum products.

Advances in the technology of energy conservation through improved utilization of fossil energy sources would be pursued in areas such as:

Advanced combustion systems and emission control systems;

Basic research on the physics and chemistry of fossil fuels; and

Other advanced techniques for using fossil fuels and reducing environmental effects.

ASSISTANT ADMINISTRATOR FOR NUCLEAR ENERGY

The responsibilities for nuclear energy development and operation of facilities for enriching uranium would be under the Assistant Administrator for nuclear energy. He would carry forward present AEC research on long term solutions to energy needs. His responsibilities would include studying new nuclear technologies, developing them, and working with industry to bring them to commercial demonstration. This effort involves a close working relationship with industry to ensure technology transfer and effective, cooperative R. & D. efforts.

Responsibilities for R. & D. on systems for conversion of fission energy include:

Civilian power reactors, such as the liquid metal fast breeder reactor (LMFBR), light water breeder, and the gas-cooled concepts;

Safety research on nuclear reactors;

Supporting technology relating to components, fuel preparation and recycling and auxiliary systems;

Technology for providing on-board electric power for spacecraft;

Improved nuclear propulsion systems for submarines and surface vessels; and

Peaceful application of nuclear explosives.

Research and development of systems for the conversion of fusion energy would include:

Research on the fundamental laws of physics relevant to the magnetic confinement of thermonuclear plasma;

Experimental production of sustained thermonuclear reactions; and

Design and fabrication of devices to demonstrate the feasibility of controlled fusion.

This research would be closely coordinated with laser fusion efforts.

A significant responsibility would involve the operation of facilities for enriching uranium and performing research to develop and improve enriching techniques. AEC is now attempting to transfer technology to industry with the intention of inducing industry to construct additional increments of uranium enrichment capacity. In the meantime, the sole source of the United States supply of uranium for commercial uses comes from these Government-operated production complexes.

A continuing responsibility would be exercised over health, safety, conservation, and environmental aspects of all nuclear systems being developed. Included in this work would be performance of nuclear waste management activities.

ASSISTANT ADMINISTRATOR FOR ENVIRONMENT, SAFETY, AND CONSERVATION

Protecting the environment, safeguarding public safety, and conserving resources must be considered in developing all energy systems. Such concerns inevitably have an effect on hardware development for any specific energy technology. These would be the responsibility of the Assistant Administrators for Fossil Energy, Nuclear Energy, and Advanced Energy Development. Many of the most critical problems in energy research and development are associated with energy demand or consumption questions or with more fundamental environmental or safety questions that are not necessarily directly related to the development of a fuel supply technology. These matters would be the responsibility of the Assistant Administrator for Environment, Safety, and Conservation. He would also be able to provide the Administrator with a general assessment of the environmental, safety, and conservation aspects of the technologies under development.

This Assistant Administrator would have a charter to:

Carry out general R. & D. programs in the areas of environmental protection including waste management, transportation, health and operational safety, and alternative conservation technologies arising from energy sources or uses;

Provide a focal point for coordination of environmental, safety, and conservation issues with other agencies; and

Review ERDA programs and facilities for compliance with relevant environmental, safety, and conservation standards.

Examples of topics that might be the subject of research by this element include:

Basic biological and medical problems;

Environmental, health, and safety impacts on human populations and various ecosystems;

Effect of thermal discharges on aquatic life;

General waste management;

Safety, cost, and risk-benefit factors in various energy systems;

Conservation factors in alternative means of increasing system efficiencies; and

Fire and safety reviews of ERDA facilities.

Safety responsibilities exercised by this Assistant Administrator would extend to the oversight of Federal facilities under ERDA control to assure that they are operated in a safe manner.

ASSISTANT ADMINISTRATOR FOR RESEARCH AND ADVANCED ENERGY SYSTEMS

The Assistant Administrator for Research and Advanced Energy Systems would have important development responsibilities. We must recognize that there is need for energy research and development in areas that fall outside both the nuclear or fossil categories but which ERDA could profitably study. Work being performed by this Assistant Administrator would support both fossil and nuclear programs and also involve other advanced energy source options.

This Assistant Administrator would have research responsibilities which broadly relate to current and future energy missions including:

High-energy physics to achieve better conceptual understanding of matter and energy;

Medium- and low-energy studies of nuclear structures and processes;

Fundamental studies of the properties of materials and phenomena related to their potential use in energy systems; and

Studies of processes and interactions on the molecular or atomic scale related to energy applications.

In addition, research and development work would be performed on new technologies which have long-range potential for generating energy. Efforts would include developing for commercial appliction:

Geothermal and solar energy;

Transmission and storage of energy;

Magnetohydrodynamics and other advanced cycles; and

Other advanced concepts such as conversion of tidal and wind energy, and advanced automotive systems.

ASSISTANT ADMINISTRATOR FOR NATIONAL SECURITY

The Assistant Administrator for National Security would continue to exercise responsibilities for research and development of nuclear weapons, the production of weapons materials, and the testing, manufacture, and reliability assessment of weapon components and systems. His activities would be coordinated with the Department of Defense.

Responsibilities for research and development on nuclear weapons and related programs include:

Development of nuclear weapon components and systems; and

Laser fusion systems capable of providing specified energy units to a laser-fusion target.

The reactor products necessary for fabrication of weapons will be produced in Government-operated reactors and would be the responsibility of the Assistant Administrator for National Security. He would also perform international security functions including export-import control of the goods, services, and information necessary to protect national security.

ERDA MANAGEMENT AND OPERATION

The Administrator would, of course, have the flexibility to run his Agency as he saw fit. But if we were to project from present successful practices, we would assume that ERDA would probably be managed and operated along the following lines.

The ERDA Administrator would be responsible for setting agency policy and program objectives and for allocating the agency's resources. The Administrator would draw upon a central staff to provide guidance and agency control in the financial, legal, personnel, and other administrative areas. A strong policy planning and analysis group would also be available. In the assignment of priorities and

allocation of funds, each Assistant Administrator would propose requirements for his programs.

The principal staff of operating divisions, composed of individuals with strong technical-management backgrounds, would provide program direction and assessment. Principal responsibility for contract administration would be assigned to managers of field offices, who will report organizationally to the Administrator.

ERDA would operate to draw upon existing strengths. The agency would begin with existing plant and laboratory facilities and technical organizations of outstanding capability, competence, and versatility. Clearly, the existence of a large-scale fossil fuel industry with its own technical competence and resources makes possible a wide range of patterns and opportunities for Government-industry cooperation.

Each Assistant Administrator would have flexibility in selecting the best means for conducting research and development under his responsibility. Available options would include using the national laboratories, contractors, other agencies, universities, and nonprofit organizations.

TRANSFER OF NUCLEAR WEAPON FACILITIES

In various public discussions of possible ways of realigning our Federal energy research and development structure, there have been some questions about the wisdom of transferring the AEC nuclear weapons program to ERDA. Because this is a most important issue and because we at AEC feel strongly about it, I would like to set forth our views on this matter in some detail.

We believe that it is important to the successful performance of both our defense and civilian programs that the AEC's nuclear weapon activities be continued within ERDA.

The framers of the original Atomic Energy Act of 1946 were concerned with the problem of establishing independent, civilian control of a then newly discovered and powerful source of energy for both military and nonmilitary applications. We believe experience has demonstrated their wisdom and foresight in forming a separate agency, free from the direct pressures of military operational requirements, to develop and apply a technology having applications in both the military and civilian spheres.

Nuclear weapons represent basically an application of large energy sources. Weapon research and development and the production of nuclear weapons involve the investigation of these energy sources and their application in highly sophisticated ways. The nuclear design laboratories, their associated test sites, and the integrated weapons production facilities represent one of the largest and most expert concentrations of scientists, engineers, mathematicians, and their facilities in the Nation. These capabilities can and have been brought to bear on military as well as civilian energy problems in the most effective way. During the past 25 years, the multidisciplinary laboratories have made substantial contributions in such nonweapons energy fields as reactor development, controlled thermonuclear research, plowshare, and the space power program. You are, of course, aware of the potential of laser fusion, an energy alternative being developed by these laboratories. These researchers are also the leaders in geothermal research and are building a capability in the solar field. These capabilities are essential to ERDA's success in a broadened energy role.

We believe the AEC practice of using these resources for developing energy alternatives should be followed within ERDA. The scientists and engineers at these facilities are eager to apply their capabilities to energy problems and will be needed to assure adequate technical skills in a rapidly growing technology. In them ERDA will acquire a valuable national resource.

ORGANIZATION OF THE NUCLEAR ENERGY COMMISSION

The spectacular growth of the nuclear power industry in recent years has greatly increased demands upon the AEC for regulating the peaceful uses of nuclear energy. As we have long anticipated the time has now come when the scope and magnitude of the regulatory function requires the undivided attention of one agency. The proposal to provide for a separate Nuclear Energy Commission (NEC) is another step in the evolution of the Government's involvement in controlling nuclear development and use.

The Nuclear Energy Commission would consist of:

Five Commissioners;

An executive director of operations;

A general counsel to provide legal advice and assistance;

A controller for financial management;

A secretary and public affairs officer to assist in the conduct of the Commission's business and its communications with the general public;

A policy analysis office to conduct broad policy planning, assessment of resources and operational planning and control functions; and

A regulatory line staff reporting through the executive director of operations. This staff will operate in the areas of:

Standards—setting standards for licensed nuclear activities involving nuclear reactors, other nuclear facilities in the reactor fuel cycle, and the possession, use, transportation and disposal of nuclear materials in civilian activities;

Licensing—review and evaluation of license applications for nuclear facilities and materials;

Inspection and enforcement—inspection of licensed nuclear activities to determine compliance with NEC's regulations and licensing provisions; and enforcement where necessary.

Confirmatory assessment—independent assessment of research requirements relating to reactor safety and other regulatory responsibilities. This would include the verification of research results for applicability to safety standards, design features for reactor safety, and safety and environmental aspects in other areas of nuclear application where NEC has responsibility.

Standards, licensing, and inspection and enforcement (regulatory operations) exist in the current organization under the AEC's Director of Regulation. Confirmatory assessment is a new organizational responsibility. It would give the NEC an independent capability for developing and analyzing technical information related to reactor safety, safeguards, and environmental protection in support of the licensing and regulatory process.

The Commission would continue to have the assistance of the licensing and advisory boards of the AEC including:

The Atomic Safety and Licensing Board Panel,

The Atomic Safety and Licensing Appeals Panel, and

The Advisory Committee on Reactor Safeguards.

NEC would be responsible for licensing and regulating the civilian applications of nuclear materials and facilities. NEC's responsibilities would embrace a comprehensive set of programs designed to ensure that activities involving nuclear materials and facilities are conducted in a manner consistent with public health and safety, environmental quality, national security, and antitrust laws.

The Commission would carry out exclusively the regulatory functions of the present AEC, including:

The establishment of policy and oversight of the regulatory operations;

Rulemaking;

Adjudication of licensing and enforcement cases; and

Assessment and allocation of management resources.

The regulatory responsibilities would encompass the licensing and regulation of all nuclear utilization, production, and processing facilities for industrial, commercial, or other licensable purposes, including transportation, import or export of nuclear materials, and the disposal of radioactive wastes. This would involve diverse uses of nuclear materials and facilities, such as in electric power generation, nuclear research, and medical diagnostics and therapy and industrial radiology.

NEC would have the statutory authority to engage in contracting for confirmatory research which the Commission deems necessary for the discharge of its licensing and regulatory functions. Furthermore, NEC would be able to obtain appropriate research and development data developed by ERDA and other Federal research agencies and to examine and analyze the data. ERDA and other Federal agencies, to the extent practicable, would be expected to: (1) furnish NEC, on a reimbursable basis, such research services as the Commission deems necessary for the conduct of its functions, and (2) cooperate with respect to the establishment of priorities for the furnishing of research services requested by NEC.

NEC would have the responsibility for planning, budgeting, and evaluation of results of the light water reactor safety program. The Loss of Fluids Test and Power Burst Facilities would be transferred to ERDA, which would continue to perform the day-to-day management of these programs on a reimbursable basis under agreement with NEC. In the areas of biomedical and environmental research, waste management and transportation, NEC would be provided additional funding to initiate research appropriate to the regulatory responsibilities for the protection of public health and safety.

At the request of the Administrator, the Advisory Committee on Reactor Safeguards would conduct safety reviews of ERDA nuclear activities and facilities. NEC would be authorized to license the following categories of future ERDA facilities: (1) demonstration liquid metal fast breeder reactors when operated as part of power generation facilities of an electric utility system, (2) other demonstration nuclear reactors when operated as part of a power generation facility system, (3) facilities used primarily for the receipt and storage of high level radioactive wastes resulting from licensed activities.

ERDA and NEC would both have important rules in assuring that new types of nuclear power plants met the most exacting standards in terms of health, safety, and protection of the environment. In the early stages of research, ERDA, like AEC, would be fully responsible for all health, safety, and environmental aspects of reactor design. When, however, design has advanced to the point where it is possible to build a reactor plant which may demonstrate commercial feasibility, NEC would begin to exercise its licensing role as it would over any commercial nuclear power plants.

Under this arrangement both agencies would be working together to achieve the highest level of safety and reliability in new plants. Licensing at this point in the commercial demonstration stage would also bring into play a development process that would make the best use of the talents of both NEC and ERDA. NEC review would assure that the reactor could meet appropriate safety standards, but it might also demonstrate that existing standards were not relevant and required change. In this case NEC would have an opportunity to revise its standards before the new reactor design came into full commercial use. In no event, of course, would a new standard be compromised to satisfy a development objective. On the other hand, the NEC review at this point in the developmental stage might demonstrate the need for design modifications. Licensing reactor demonstration facilities would also enable NEC to adjust its staffing and programs to handle the licensing of new reactor types before they come into full commercial use. Under present arrangements AEC Regulatory staff performs safety review for AEC commercial demonstration plants. The Liquid Metal Fast Breeder Reactor demonstration plant will, of course, be licensed by NEC.

Licensing will also be extended to new facilities used to process and store high level radioactive wastes generated by commercial reactors. This will assure that such new facilities meet the appropriate safety standards. Of course we expect that NEC and ERDA will work closely together to exchange information. The objective is to develop safe facilities which incorporate the most modern technology.

AEC is currently working with industry on the transfer of technology necessary to permit commercial operation of new uranium enrichment facilities. When private commercial uranium enrichment facilities are constructed they would be licensed by NEC.

To summarize, the proposed Nuclear Energy Commission is designed to assure protection of the public health and safety in civilian nuclear activities. The new organization would eliminate the appearance of regulatory and developmental conflicts in administering the nuclear energy program. The reorganization would maximize regulatory objectivity and impartiality, increase public confidence in nuclear regulation, permit the Commissioners to concentrate exclusively on regulatory issues, and create a fully independent regulatory agency which the rapidly maturing nuclear industry requires.

I have tried to describe the principal features of ERDA and NEC as they are outlined in S. 2744. I believe that we need both of these organizations now: ERDA, to provide a vital and aggressive energy research and development program; NEC, to assure the expedient regulatory review of nuclear power plant construction and operation without compromising environmental, health, or safety standards. We are fortunate that members of the Congress and the Administration have acted promptly and decisively in this way to meet the crisis which now confronts us. I commend you, Mr. Chairman, and your subcommittee for calling hearings promptly on this important legislation, and I offer the full support of the Atomic Energy Commission in perfecting the bill now before you.

ENERGY NEEDS AND THE EFFECT ON THE ENVIRONMENT

Senator RIBICOFF. Commissioner Ray, and Mr. Ash, one of the great problems facing the Nation is how we balance our energy needs with the conservation of our environment. I personally don't believe that they are inconsistent.

I believe that now that the price of energy as reflected in the price of oil keeps going up beyond $8 a barrel, it is economically feasible at world competitive prices to develop energy and, at the same time, preserve our environment.

Don't you think if we bring the environmentalists in with the planning of new energy resources and alternate supplies of energy, we can avoid these confrontations between those who want more energy and those who want to preserve the environment. I personally believe we can have both if we plan properly. I would like the comment from both you and Mr. Ash as to how we reconcile the environment with the increased supply of energy.

Dr. Ray. Mr. Chairman, I agree most fervently with the things you have said. I think we have had too long a period of time in which we have been polarized, in which those who would develop resources have been in a position of opposing those who would ask for a greater restraint and greater consideration for the quality of environment and for greater efficiencies in uses of those resources.

The time has come, I think, for the advocacy or argumentative phase to be terminated and for people to work together, recognizing that what we need is a balance, a reasonable use, combined with a reasonable concern for environment and the quality of life.

We have considered conservation not alone in terms of natural resource conservation and use but also in terms of increasing efficiencies in energy conversion. The latter, which is often a very inefficient process, is a very important part of the recommendation in this 5-year, $10 billion program. On the 5-year basis, conserving energy and energy resources is recommended for expenditures of about $1½ billion of the total $10 billion.

We feel that much can be done in this area, particularly in coal research. As the cost of coal rises, especially that of low sulfur coal, the market itself will provide a sufficient return on the investment so that the coal companies will be able to afford the rehabilitation of strip mining areas.

We must, in this case, recognize that good conservation may mean more in terms of good rehabilitation than in terms of prohibition. I think that this is an area in which we must work very hard.

Senator Ribicoff. Mr. Ash.

Mr. Ash. I would just want to add one observation to that, you will notice over there to your left——

Senator Ribicoff. I wonder if you would have a member of your staff point out the role of conservation in the setting up of this agency as you explain it, Mr. Ash.

Mr. Ash. Yes. Mr. Zarb here will describe the role of environment, safety, and conservation as it relates to the management of the research and development administration.

Mr. Zarb. Mr. Chairman, each of the line organizations has within it an organization which is committed to environment, safety, and conservation. If you will note the Administrator for Fossil Energy Development, the same applies to the nuclear development, and then you find a crosscutting Assistant Administrator who has responsibility, primary responsibility, for environment, safety, and conservation. The same applies in the area of advanced energy systems where we find the presence of a conservation division within that group. So the organization envisions a conservation environment presence in each of the

line organizations with a senior official crosscutting the entire organization with that primary interest.

STAFFING WITH TRUSTED PEOPLE

Senator RIBICOFF. I would hope that when the time comes to staff that agency that there would be placed in these positions men and women who the conservationists of this country trust and whose opinions they can rely on. I believe that is very important.

I believe it is also important to avoid a situation that took place in the past few days when one agency on its own orders, extended the years in which the emission standards on automobiles were to be effective without the consultation of Mr. Train. I mean these are the actions that cause shock waves to go through the environmental segment of our Nation, and raise doubts as to the reconciliation between energy and environment.

Would you want to comment on this situation?

Mr. ZARB. Mr. Chairman. I want to add that the senior administrators, all five of them, will be confirmed by the Senate, and it is our plan to carefully select these people so that they bring the balance that you suggest.

EMISSION STANDARDS

Senator RIBICOFF. Now, from a management standpoint, do we get into a situation where you extend the emission standards on automobiles where they were or were not justified without consulting with Mr. Train of the EPA who had a responsibility to play a role in this, I am just curious.

Mr. ZARB. I am not familiar with the fact that that consultation didn't take place but if it did not, obviously, it was incorrect.

Senator RIBICOFF. As I read the press, Mr. Train indicated that he had not been consulted before this decision had been made.

Mr ASH. I can describe what I know of it, and I think its factually correct, that there were discussions with Mr. Train, not that everybody came to an agreement, EPA published its regulations and then proposed legislation was sent to the Congress that was contrary to that. It was sent not by submitting the proposed legislation itself to the EPA but after considerable verbal disscussions with the EPA as to the differences of opinion and as to the actions contemplated.

I think the news version, and I checked on it myself, although what I have is second hand because I wasn't a party to it. I was told by Mr. Sawhill, who is here and who did have that discussion with the EPA, that such a discussion took place even though the news reported that it didn't. Now maybe the difference is whether the discussion took place. Or whether a specific proposed legislation was put in front of them, and I think that is the minor difference. Mr. Sawhill himself had that personal discussion with the proper authorities in EPA before there was a contrary position proposed.

Senator RIBICOFF. One final question before I use up my 10 minutes, Commissioner Ray.

ALTERNATE SOURCES OF ENERGY

Your report to the President, as I read in the Wasington Post, it brought the conclusion that Mideast oil was still needed to supply

about 20 percent of our energy needs for the next 15 to 20 years. Is it your feeling then that alternate sources of energy cannot make us self-sufficient in the next two decades?

Dr. RAY. No sir. I am not sure of the source of that particular comment. But because of the way in which the report was drawn, with many, many meetings involving large groups of people, the drafts as they were developed were quite freely available. There was much discussion about the Nation's ability to replace oil now imported from the Mideast. Table 2.2 summarizes our conclusions.

(Table 2.2 is printed in the appendix; see p. 329.)

Dr. RAY. Now, whether this Nation continues to import Mideast oil depends upon many, many decisions, most of them outside the field of research and development.

From the standpoint of domestic fossil fuel resources, not just oil, but including coal as well, and the technology to convert coal into a liquid fuel, this country has all of the resources that it would need to be self-sufficient provided we can learn better ways to make it economical. We must also make the right decisions, both from the standpoint of cost and the standpoint of environmental affects, in using these resources.

SELF-SUFFICIENCY IN ENERGY—HOW LONG?

Senator RIBICOFF. All right then, the next question: If this Nation makes the right decisions, how many years will it take to make our Nation self-sufficient in energy?

Dr. RAY. I think we would all love to have the crystal ball that would give us that answer.

Senator RIBICOFF. Well, from the work that you have done, both you and Mr. Ash have been involved deeply in this field, if we make the right decisions, the right commitment of money and technology how many years would it take this country to be self-sufficient in the entire field of energy for our basic needs in this Nation?

Dr. RAY. In my judgment, if we do all these things we will have the capability to know whether we can or cannot be self-sufficient. We can also decide which technologies can in fact be applied to what end within this 5-year period by 1980. We can probably gain that knowledge. But to do the actual development to commercial scale will require an additional time, and it is my judgment that if we start now it will probably take about 10 years before we can, in fact, be self-sufficient.

Senator RIBICOFF. Mr. Ash, would you like to comment?

Mr. ASH. Mr. Chairman, to add to what Dr. Ray has said, and I want to particularly add this because I know there has been some confusion and misunderstanding. The President's statement contemplated a capability for self-sufficiency, which is somewhat different from self-sufficiency and it does make a major difference. The capability for self-sufficiency can come from the development of our domestic resources, and can even come from different means of acquiring our imported resources so we don't come to a state of dependence as we now have, can come from such things as more storage capacities that we can develop within this country because it may not be in our best national interest 5 or 10 years from now, or whatever, it may not be in our best national interests to pump out

of this country all of the soil that we have or use all of its coal. We still may want to be importing for quite other reasons, but the main point is to have such a capability for self-sufficiency that we will not be blackmailed or cannot otherwise be put into an adverse position vis-a-vis other countries.

So I think we have to make clear that the President is not saying we are going to produce all the energy we need in this country. We are going to have the capability to be self-sufficient but with such capability we then can bargain with the rest of the world in quite different ways than the bargaining position we have now, and I think that is a point that needs to be clarified because I know there has been a fair amount of confusion on it.

Senator Ribicoff. Thank you.

Senator Javits.

Senator Javits. Thank you.

A POSSIBLE RECESSION

Mr. Ash, one of the deep problems which is troubling the country is the almost inevitability of a recession in 1974 based on the alleged energy crisis.

Now, some estimates of unemployment range to 6 percent which would be roughly speaking a one-third increase over present unemployment. It is expected to have catastrophic effects upon recreation and upon vacation resorts, and upon road travel with the enormous amount of involvement which that implies.

Now, is there anything in this connection in your gearing up to meet this crisis that you can tell the country. America can stand bad news but it would like to know where its at, and there is no reason why these ideas should overdiscount the situation. Is there anything as the Budget Director that you can tell the country on that score as to what the administration really expects?

Mr. Ash. In this case I will speak as a member of the Troika which embraces more economic and fiscal considerations. As you know, just this last week the CEA has come up with the best analysis that could be made within the executive branch, including the CEA's work, the Treasury's work, our own work. It concluded that if the oil embargo continues through the whole course of 1974, then the adverse effect upon our gross national product from the energy crisis in total would range someplace between a 1 and 2 percent reduction of real gross national product, would generate an unemployment rate which is now 4½ percent—generally considered very high employment considering the mix of the moment—into 5 percentage points, hopefully not over 6. So your numbers are just right in that respect, Senator. These are based, of course, upon the best premises and assumptions that we can make at the moment, including the one that the embargo will continue.

Now, the basic energy policies that underlie the administration of the energy programs are, first, that everybody in this country keeps healthily warm and, second, that we maintain jobs and employment. To do that with what is obviously a total limitation of energy available, requires that that limitation be apportioned in ways to achieve these basic objectives.

The first reduction, of course, to the extent that it can be administratively brought about, is to reduce the unnecessary uses of energy including a fair amount that goes on in automobile travel.

Then, as one works down this scale of priorities we believe it is essential in protecting jobs to particularly project those jobs in industries that interact in the economy in such a way that they bear on many other jobs. Some industries, of course, are so critical to the whole running of the economy that some down time there and job loss translates to 1, 2, 5, or 10 jobs lost elsewhere.

There are other industries, that while there may be some jobs lost, there will not be the same effect on the economy and the basic objectives we have. I do not mean to say we can administer it perfectly toward those objectives, but the basic objectives are to have those priorities in mind and minimize the effect on the economy. Clearly, there will be an effect on the economy.

Now, if this projection is true, and it is based on a number of premises, it is very hard to know, then, whether minus 1–2 percent effect on real GNP that comes from the energy crisis itself will reduce the growth of, say, 2½–3 percent, down to a one to one and a fraction percent of real GNP growth for the whole of the year.

As best we can forecast, the impact will fall most adversely upon the first quarter and less so on subsequent quarters of the calendar year 1974.

What will be the problems? The problems will largely be these: They will be the maldistribution of our energy resources. With 7 percent less energy available, which is about the amount that would be the reduced level of energy, assuming the embargo continues, it is possible to distribute it in a way that would be almost no adverse effect on the economy if everything worked ideally. But that is based upon the premise that with 2 million barrels per day taken out; that is, in particular areas with particular uses, we can immediately rearrange the whole distribution system and even the refinery system to come down with a new distribution pattern that is fully optimal. There will be some discontinuities, there will be some problems of adjustments that will particularly affect us in the period immediately ahead. The real problem is not that on the average we can bear this energy reduction and bear it with minimal effect, but some particular instances will inevitably arise with a problem much bigger than the average, and there is the problem that has to be managed. That is the kind of problem that Bill Simon will be managing, which is to make sure that when somebody calls up from New Hampshire and says "I am turning the utility off because I don't have oil today, that we immediately work in a highly expediting fashion to make sure he gets that oil even when in average, our problem is a barrel problem.

That is the nature of the problem and that is why I say that in the Federal Energy Administration we are going from a change of mode dealing with macropolicy, macroeconomics, we are now getting down to a job to make sure a trainload of coal is moving North when it should be moving North or a boatload of crude is being distributed to the right place to go into the right utility or industrial or other use. That is the nature of the problem that we are down to now, and the whole administration mode has to change to deal with that instead of just the broad policy of what is the problem in total and what are our principles in total.

Senator Javits. Thank you. It is very helpful. Mr. Chairman, do I have another minute or 2?

Senator Ribicoff. Yes, you have 2 more minutes.

Senator Javits. Two more minutes?

WHAT IS THE DECISION ON RATIONING?

Mr. Ash, I have a corollary question to that. Has the administration made a policy decision that this administration on which our whole future hinges is going to be done by law and allocation and rationing, et cetera, or have they come down to the other side that it is going to be done by taxes or exhortations to be patriotic, et cetera?

Mr. Ash. The statement of the President is one that still holds and that is that it would be very preferable to solve this problem without going to a gasoline rationing system. However, such a system is being developed and prepared just in case, and certainly the problem is going to be solved one way or the other but we strongly believe that solutions other than rationing are preferable if they are workable. Those solutions include voluntary efforts and we are very pleased at some of the results that we see present in the voluntary response. There are already some mandatory programs, there is consideration, as you know, of plans other than rationing that might precede rationing, but we are not going to let that moment pass when we must make a decision of rationing or not, and by default fail to make the right decision when that time comes.

WHEN CAN WE EXPECT A DECISION ON RATIONING?

Senator Javits. Just one question on that. I happen to believe in rationing, and I am for it and I wish to so declare, but by what date do we have a right, in order not to let time and the opportunity to slip away from us, to expect this decision.

Mr. Ash. The first date when it must be made is variable depending upon the response. If, for instance, the voluntary response went so far as to itself reduce consumption to the full level needed then, of course, the date could be out to infinity. If, on the other hand, the voluntary response is negligible, then a decision would have to be made in just a few days. We are watching weekly that voluntary response. The first 2 weeks, highly favored by the weather but nevertheless the first 2 weeks, showed us that we were getting a good response in terms of reduced energy consumption.

But I would say that in my own judgment, not to speak for anybody but myself that we have got to come down one way or the other before this month is over and maybe that one way is not rationing, but maybe on the other hand it will be, but we don't want to pass the point in time when a decision has to be made to get on with it.

Senator Javits. And in your judgment it is by the end of December?

Mr. Ash. That is my judgment of when we must come down one way or the other, or to put it in the converse, that given the way we at this moment see the voluntary and mandatory efforts working we believe that we will not have passed a critical date in the next few days, at least and probably not until sometime well on into this month.

Senator Javits. Thank you very much. Thank you, Mr. Chairman.

Senator Ribicoff. Senator Nunn.

LICENSING NUCLEAR PLANTS

Senator Nunn. Dr. Ray, I have one question that relates to nuclear plants and licensing. I have been told that when antitrust

investigations or actions are pending concerning a nuclear plant, the licensing is delayed even though whatever the outcome of the antitrust action, the plant is going to be built. In other words, I am asking the question why hold up licensing of a nuclear plant for an antitrust action that does not relate to whether or not the plant is going to be built?

Dr. RAY. I would be pleased to respond to your question, Senator, but our expert in this is Commissioner Doub—and, with your permission, I would like to toss this question to him.

Senator NUNN. Certainly.

Mr. DOUB. Senator, the possibility of an antitrust hearing holding up the licensing of a plant to prevent the plant from coming on line is something we are very much aware of. At the present time no plant is being held up because of an antitrust hearing.

Senator NUNN. This morning I was told that a plant is being held up because of an antitrust hearing.

Mr. DOUB. I don't believe that is true at the present time, but I don't want to minimize for 1 minute the delay potential inherent in the amendment to the Atomic Energy Act a couple of years ago to provide for antitrust review in advance of the issuance of a construction permit. This is being very carefully looked at by the Atomic Energy Commission and by the administration.

If the situation is deterring our nuclear capacity in meeting the energy needs of this country and is imposing economic penalties of delay in bringing these plants into service then I personally, and I think I can speak for the Commission, would favor legislation.

Senator NUNN. I can certainly understand a holdup on the basis of safety or anything of that nature but on the basis of having nothing to do with whether the plant is going to be operational or under some ownership or some system I cannot see why an antitrust action would hold it up and I would like to have any kind of amplification you might want to add for the record.

Mr. DOUB. I will be glad to supply that, sir, together with our legal counsel's opinion that we cannot issue a construction permit until after an antitrust review and a hearing on antitrust issues, if there is one, is completed. But be assured the matter is receiving our close attention.

Senator NUNN. I will get you details of the particular plant and the information I have.

Mr. DOUB. Yes, sir.

CONCERN FOR SMALL BUSINESS

Senator NUNN. Mr. Ash, I chaired hearings last week of the Small Business Committee and we had numerous witnesses on this overall problem as it effects small business. One of the concerns that came from all witnesses—Governors from two States, scientific advisers from two States, and businessmen—was their concern that these business executives, close to 250 of them, were going to be placed in an administrative line of command. This, in my opinion, and in the opinion of many witnesses, is going to possibly dilute very much the credibility of the program, whatever the merits may be as far as the expertise.

Could you comment on whether these executives should be placed in the line of command or should they be, in effect, in an advisory capacity?

Mr. ASH. It is my understanding that those 250 or so will be available as expert advisers and provide the benefit of their broad knowledge of all of the kinds of issues that must be dealt with, but will not be given line authority over any part of this operation.

Senator NUNN. I don't think that point has been made very clear.

Mr. ASH. What we will be doing is to also recruit and hire people of expertise in this field, some of whom might come from small business, some might come from large, some might come from any place, but once those are recruited they will have to make sure that they remove all potential conflicts of interest in any work that they do as Government employees. But that is totally different from the 250 that we have read about.

OIL COMPANY PROFITS FOR R. & D.

Senator NUNN. There were several suggestions that the oil companies plow back profits over a certain level into the kind of resources that we need, whether it is R. & D. or whether it is actual natural resources. Does the administration have any plan to have this kind of legislative proposal before the Congress?

Mr. ASH. There is no plan to, but that kind of proposal has been given considerable thought, and the thought would go like this: That in order to reduce demand in the marketplace, one could do it by a higher price but at the same time one would not want the private companies, recipients of that higher price, to just add it to their profits. Instead we want to make that price increase conditional upon those moneys being spent in ways that serve the national interest. Now, that is the general line of thinking. There isn't any particular proposal that has been developed or even contemplated but nevertheless in turning up all the stones possible in seeing what things can be done along the line of thinking that has been discussed.

SELF-SUFFICIENCY IN ENERGY

Senator NUNN. I would like to ask a hypothetical question for whoever might want to answer it: Based on President Nixon's speech, I believe about a week or so ago, in which he defined this problem as a temporary problem depending on the international situation, do you view the problem as being a temporary problem? If so, would you define for us what self-sufficiency means, and you have already addressed yourself partially to that question. I am really asking: Do you view this as a temporary problem and if the Middle East nations were to resume the flow of oil on the basis that they did prior to this war, would we still have a problem?

Mr. ASH. Well, there are different degrees to this problem. We have a temporary new dimension to the problem brought about by the oil embargo and that will last so long as that embargo continues. But even when that embargo ends, there are still two problems left with us and I think the President acknowledged these as well: First, we will have gone without those barrels that would have otherwise arrived here during the period of that embargo, and that is a one-time loss that we will have to accommodate some way or other.

Second, as we all know even before the Arab embargo and going back as far as last summer there was developing an energy shortage of smaller dimensions, manageable by quite different methods, which will not go away even when the embargo is over. We will still have a residual problem to deal with on a lesser dimension, of course, and therefore probably by quite different techniques.

Then when we come to the matter of self-sufficiency, which will be a number of years hence and until that time we will still have a degree of a problem, I think I described earlier that we need and are working toward a capability for self-sufficiency rather than a program where we will not be doing any importing at all. But we certainly want to get into a completely different bargaining position than we have now as we do depend upon imports. We must get into a position where we cannot be blackmailed or otherwise held up by virtue of self-contained abilities for developing our resources and import and storage patterns that we might by that time develop.

Senator NUNN. So it would be very difficult, with all these ramifications to define this as a temporary problem, would it not?

Mr. ASH. We have a temporary new dimension to the problem and I don't know exactly the context in which those comments were made but I know the President has many times acknowledged that we have a long-term issue to be dealt with. For that matter, as you know, on April 18 of this year, long before any embargo, he identified a problem that we need to work on and need to work on for the long term. So it is a temporary dimension but he himself on April 18 identified the problem as a long-term one.

Senator NUNN. Well, I am basically concerned that the American people be given the candid facts even though they may be unpleasant and I think they can respond with initiative and with many sacrifices. But, I think if they believe there is a solution right around the corner, this is going to delay any kind of meaningful effort which is absolutely essential at this time. I will just make that observation.

PERSONNEL PROBLEM

Let me ask you one other question relating to the administration of this program. Of course, we are going to have to deal with it every day through constituents. The backlog in the regional office in Atlanta alone is 10,000 cases and they do not have enough personnel there even to answer the telephone for periods of days at a time. At one point in time we had to send one of the people from our Atlanta office to the regional office so the Washington office, their superiors, can get in touch with them.

In other words, the allocation program is bogged down and it is in a very bad situation administratively, and the testimony we had last week indicated that, to me, at least, that instead of getting the very finest people in government involved in the administration of this problem, the various agencies are sending surplus people that are not doing other things. I am not criticizing any of these individuals, but I direct this question to you because I think you can deal with this problem. Is an effort being made to get the finest people we have in various agencies in this emergency and to put them in these regional offices as well as in the Washington office to really deal with this problem from an administrative point of view?

Mr. Ash. Well, OMB is not an operating agency. From time to time there arise crises that need special management expertise and the one you have identified is such a crisis.

Mr. Frank Zarb on my left, Assistant Director of OMB, has personally taken charge of solving the very problem you have just brought up and I will ask him to respond.

Mr. Zarb. Senator, any startup of new situations such as this brings with it the kind of problems you just articulated and in this case it includes a backlog of inquiries that needs to be cleaned up quickly. While the organization responsible for this thing is putting permanent Regional Directors on the staff we have taken steps, dispatched a number of our own people from OMB to the regional offices with instructions of how to go about resolving the outstanding situations and to help in the building processes as the building takes place. We think we can bring that under control pretty quickly.

Senator Nunn. Thank you, Mr. Chairman.

Senator Ribicoff. Senator Percy.

MORE ON LICENSING OF NUCLEAR PLANTS

Senator Percy. Mr. Chairman, I would like Commissioner Doub to have a couple of minutes to finish the comment on the proposal to virtually halve the amount of time required for the licensing of nuclear energy plants and what relationship that has to safety. Whatever material he would like to incorporate in the record to amplify his statement, I would like to ask unanimous consent that it be included at that point.

Senator Ribicoff. Without objection.

[See appendix, p. 529.]

Mr. Doub. Thank you, Senator. I will amplify it later in the record because of the limited time we have available. But to add to what Mr. Ash says if the purpose of S. 2744 is to come to grips with the problem of marshaling the resources of our energy supply, I think it is deserving of prompt enactment. It is essentially noncontroversial. It represents the culmination of 10 years of debate on the subject of can an agency both regulate and develop the nuclear resources of this country. The bill, the provisions of the bill, I think are realistic, I think they come to grips with the problem and they represent the dynamic nature of regulation. If regulation is not dynamic, then lethargy and stultification set in. That is one of the problems of making regulations responsive to the public interest.

The President has directed the Atomic Energy Commission to determine what can be done to reduce the time required in getting these plants on line from the current 9 to 10 years down to 6.

With a new technology, with only 39 operating nuclear reactors, they have been treated in the regulatory process as customized, and indeed they are custom design units.

It is perfectly obvious to the Commission, as it is to the industry, that standardization will not only facilitate more expeditious licensing and more depth in the review process but will contribute significantly to safety. We feel that the level of maturity in the industry has reached a point where standardization can go forward, and the industry has been advised that they should standardize their reactor designs.

LIMIT ON HORSEPOWER RATES

Secondly, we have put a limit on the so-called horsepower rates. The Commission in a policy statement about a year ago, a year and a half ago, said the 1,300 megawatts electric is the maximum application that would be accepted. Now, this limit on the horsepower which is being clarified to limit output to 3,800 megawatts thermal, the move toward standardization and bringing some sense into the siting area, are the goals right now of the Commission which will reflect themselves in the expedited licensing proceedings.

This may require legislation. The administration has asked us to have legislative alternatives at an early date for consideration, and they are presently being developed—they will, of course, be submitted to the Congress.

There are two points to keep in mind, I think. One is that under no proposals can the quality of the safety and environmental review or public participation be sacrificed. Under any alternative they would be maintained.

CONSTRUCTION DELAYS

Now, the one area which is to a degree outside of the control of at least the Atomic Energy Commission is the problem of construction delays. Construction problems have been extending. There have been numerous meetings with Mr. Ash, which he is better prepared to talk about than I, on this subject of what can be done to bring more discipline and greater expedition into the matter of constructing not only of nuclear plants but of other large construction projects. That matter is receiving very close attention by the AEC and the administration.

I think the President's objective is achievable. There will be a transition as we move to standardization but it is achievable, and the credibility of the licensing process should be not only maintained but enhanced with the enactment of the Nuclear Energy Commission provision of S. 2744.

Senator PERCY. Commissioner Doub, I would like to come back to you when my next time comes around and I will give you a moment to think about this. In an editorial of December 2d in the New York Times you are quoted as saying, "Discussions with utility management produced the consensus that no significant acceleration of construction programs was possible for entirely economic reasons." I will come back to you and see if you can amplify that.

A 4-DAY WORK WEEK

Mr. Ash, you and I both came out of industry. Our modern Illinois follows the Lincolnian admonition "to think anew and act anew." I am in line with Lincoln. I spent this past weekend exploring with many of our former mutual colleagues in business the concept of simply going to a 4-day work week in America. I think it is an idea whose time may have come. It is no longer a radical idea for many of our most conservative business colleagues. It makes a lot of sense to many of them that I talked to this weekend to study this in their own plants, to see whether or not a full schedule of 40 hours could be done in 4 days, 10 hours a day. It would automatically save 20 percent of

the energy consumed by every employee going back and forth to work each week. Possibly, to keep the economy stimulated, the retail shops could operate generally at the time when the plants are not operating. To discourage 3-day weekend trips, the children could possibly be kept in school 5 days a week. That would tend to keep families near home on their day off.

I am starting my studies intensively to see whether we shouldn't seriously go to this idea. In your judgment, is it the kind of an idea that Mr. Simon and his new Administration should undertake as a very serious program of study, to see whether or not we should move in this direction to the greatest extent possible?

As a corollary to that question, as we are now starting to shut some plants down and lay people off, shouldn't management and labor unions give consideration to the possibility of stretching out the work and operating on a 4-day basis without laying so many people off? The public, the taxpayer, is going to pick up that cost anyway some place along the line, whether in welfare payments or the high cost of unemployment compensation. The hardship is very great for a person who is suddenly laid off because of the energy crisis.

Mr. Ash. I certainly agree with you there is a great opportunity to think anew and along those lines. Undoubtedly there are some solutions that will not only deal with the energy problems but will deal with many other ones at the same time. I am glad that you added that we should discourage that 3-day weekend from being used for even longer travels than are now taken on a 2-day weekend.

Senator Percy. It may mean one way travel for some of them.

Mr. Ash. Unless——

Senator Percy. They can't get the gas to come back.

Mr. Ash. Unless these problems are solved simultaneously we might even have a bigger one.

PRODUCTIVITY LINK TO SHORTER WEEK

As you know, there are some legislative changes required in order to have 10-hour days but let's assume all that can be taken care of. There is another problem that can be dealt with simultaneously and I have thought about it many, many years, as I know you have. We are getting to a point in society where we have productivity which comes from a large amount of capital employment, that is how we have gained our productivity.

Now, what we have to keep our eye on is the continued use of our capital.

If we have $25,000 of capital for every employee, and that capital is being used 40 hours a week and idle 128 hours a week we are not fully using our capital, particularly today when we see in so many industries we are limited in our expansion by the availability of capital. So I would even carry your idea one step further, it may be worthwhile to have a system of work hours that would be 3½ days, and two shifts a week, and use the capital fully in 3½ days, maybe not even work 40 hours in total. In capital-intensive industries, we might have greater productivity out of 38 hours—let's say that middle day there were two 7-hour shifts, and we might turn out to even have a more effective economy.

Now, I don't particularly favor this idea, I am merely saying thinking of this kind can go on now in a changed environment and

maybe this is just what it takes to think anew of the many possibilities that we have to run a more satisfying society for everybody and a more productive one at the same time. I certainly would encourage the organization to deal with that.

Senator PERCY. Taking into account your vast resources in the executive branch, and our work in it, would you think worthy enough of this concept to direct OMB to take a good look at it and also talk with Secretary Simon? We certainly would like to question him on a number of new ideas some of us have, to see whether he can get task forces underway on them.

Mr. ASH. Assuming FEA will be in business soon, it would be a quite proper task for that organization to work on. I have had some discussion with the Department of Labor which, of course, is very interested in this and they should be a part of any such discussions as well because there are some very pertinent implications that bear on the working man's hours and conditions. But I would certainly think that the Federal Energy Administration should be able to think imaginatively in ways that maybe we haven't thought of before or haven't had a reason to think of before. We now have a reason, and this is the opportunity. I am certainly glad you mentioned that line of thinking.

Senator PERCY. Obviously the more that can be done voluntarily through organized labor and business would be best. But here are some restrictions that I ran into this weekend from businessmen who said, "Well, labor contracts require time-and-a-half pay over 8 hours a day, regardless of how many hours are worked during the week." I think labor and management can get together on that and maybe temporarily waive some of those benefits that have been gained by the labor organizations, if they realize that by stretching out the work, or by reorganizing it somehow, we could keep more people at work rather than go through some of these very painful cutbacks.

THE ENERGY PROGRAM-OIL EXECUTIVE CONNECTION

I would like to ask you something from the standpoint of consumers, because we are together now, the administration and the legislative branch, in supporting a Consumer Protection Agency. We are working out some of the details and we certainly appreciate all of the support and help that you have provided in this concept. But speaking on behalf of the consumer, in a Star-News editorial it was stated, "One consumer organization expressed the fear, not altogether unjustified, that the energy program may be turned over to oil company executives."

Would you care to comment on that?

Mr. ASH. Bill Simon is not an oil company executive and that is a starting place.

John Sawhill, his deputy, is not an oil company executive and that is a starting place. I think that there is no justification for any worry about that. But I do think it should be recognized that, first, those who are in any industry have an expertise that we shouldn't lose sight of and that we should take advantage of in getting the knowledge and information we can get from them. Second, whatever program that we carry out is one that requires the full cooperation and participation of all of those industries, particularly the oil company

industries that are so tied into this energy crisis at the moment so I think we can't just disown them and say, "we will solve the problem without you."

But I think that is quite different from saying we are going to turn it over to oil company executives.

Senator PERCY. So you would absolutely deny that there is any validity to this comment that it is going to be turned over to the executives?

Mr. ASH. I surely would.

RECOMMENDATIONS

Senator PERCY. More specifically, the Consumers' Congress has made several recommendations, if you would care to comment on those. These are to protect the consumer interests, guarantee active participation by consumer's in the formulation and operation of the national energy program; make all pertinent information available to people so they can understand what is going on; set specific time limits on suspension or relaxation of environmental standards; brook no relaxation of enforcement of antitrust laws; probe the possible role of monopolies in reducing supplies, raising prices and exacerbating shortages. In the Star-News last night, an editorial said, "We think these are worthy suggestions for the Congress and the administration."

Mr. ASH. Well, a number of those are already, of course, part of the ongoing operations of many departments and agencies of Government. Also I think one point that I can mention that is particularly responsive to the first part of your point, in the proposed organization chart for the Federal Energy Administration that I have in front of me, there is a proposed place for advisory groups to the Administrator of the Federal Energy Administration and those advisory groups as I have identified are the following: Economics, energy, business, labor, agriculture, consumer, and environment, with the deliberate intent to make sure that consumer inputs are considered by the Administrator of this organization long with many others.

Senator PERCY. I think that is very wise, and I am delighted to have it on the record, because we are moving toward giving the consumer a more structured role in Government, just as so many corporations have done. Some now have a vice president for Consumer Affairs and Interests. I think it is very interesting that they have seen fit to organize the new agency in that way, and I think it is very well for us to have it that way. It certainly will be considered.

S. 1283, IF ENACTED

Finally, Dr. Ray, could you comment on S. 1283? There is a good chance that that bill could pass the Senate soon, and it calls for a comprehensive energy R. & D. strategy which would presumably include nuclear research.

Assuming that S. 1283 is enacted, how do you envision the relationship between AEC and the national energy research project in that bill? How would ERDA fit into the management project?

Dr. RAY. Senator Percy, I would be very happy to provide such a comment for the record. I have not yet had an opportunity even to read the bill. We received it yesterday and I would like a little bit of a chance to study it before making comment.

Senator PERCY. I would ask unanimous consent that the record be held open for Dr. Ray's statement. How many days would it take you to get that?

Dr. RAY. We can certainly get it in this week.

Senator RIBICOFF. Without objection.

Senator PERCY. Thank you, Mr. Chairman.

[The information follows:]

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., December 7, 1973.

Hon. ABRAHAM A. RIBICOFF,
Chairman, Subcommittee on Reorganization, Research, and International Organizations, Committee on Government Operations, U.S. Senate.

DEAR SENATOR RIBICOFF: On Tuesday, December 4, 1973, I testified before the Subcommittee on S. 2744, a bill "to reorganize and consolidate certain functions of the Federal Government in a new Energy Research and Development Administration and in a Nuclear Energy Commission in order to promote more efficient management of such functions." During the course of the hearing, I was asked to give the Subcommittee my views on S. 1283, a bill "to establish a national program for research, development, and demonstration in fuels and energy and for the coordination and financial supplementation of Federal energy research and development; and for other purposes." (Calendar No. 567, Report No. 93–589.) I am pleased to furnish my views for the record.

My understanding of the principal provisions of S. 1283 is as follows:

Title I provides, among other things, for the establishment of an Energy Research Management Project, which would be comprised of representatives of a number of agencies concerned with energy, including one Commissioner of the Atomic Energy Commission. The project would: (1) review Federal activities in fuels and energy research and development to determine the capability of ongoing efforts to carry out the policies established by this Act and other relevant Federal policies, particularly that of the National Environmental Policy Act of 1969; (2) formulate a comprehensive energy research and development strategy for the Federal Government; (3) utilize the funds authorized to advance energy research and development; and (4) establish procedures for periodic consultation with groups which have special expertise in energy research and development. Forms of Federal assistance and participation would include, but not be limited to, joint Federal-industry corporations, contractual arrangements with non-Federal participants, contracts for the construction and operation of Federally-owned facilities, Federal purchases or guaranteed prices of the products of demonstration plants or activities, and Federal loans.

The Council on Environmental Quality would be authorized and directed to carry out a continuing analysis of the conduct of research and development of energy technologies to evaluate the adequacy of attention to (1) energy conservation methods, (2) probable environmental effects of application of technology, and (3) environmental protection in connection with energy processes.

Title II of the bill concerns geothermal energy and provides, among other things, that the Secretary of the Interior, acting through the Geological Survey, is authorized and directed to develop and carry out a general plan for the orderly inventorying of all forms of geothermal resources, and participate with AEC, NASA, and NSF in research related to geothermal resources.

The Atomic Energy Commission, in cooperation with private industry, is authorized and directed to conduct, encourage, and promote basic and scientific research related to geothermal resources.

In my opinion, S. 1283 would not provide a viable framework for accomplishing what I believe to be the joint goal of the Congress and the Administration; that is, the establishment of a Federal program which will assure the independent capability of the United States to meet its energy needs. The formation of a practicably acheivable, organizationally sound Federal structure for energy research and development is a central element in accomplishing this goal.

As I testified before your Committee on S. 2744, it is of utmost importance that the Governmental structure be organized so as to consolidate most Federal energy R&D activities within a single agency which, on the one hand, would be responsible for meeting the Federal goal in the area of research and development, and, on the other hand, would have sufficient authority in the field of energy R&D to accomplish that goal. In my judgment, S. 1283 would accomplish neither of these objectives.

Contrary to one of the purposes stated in S. 1283, that bill, rather than centralizing responsibility for energy R&D, would further fragment and diffuse such responsibility. Energy R&D work presently being carried out by a number of Federal agencies would remain with those agencies. Grafted to the present structure would be an Energy Research Management Project responsible for the allocation of funds to advance energy R&D strategies by supplementing funds for ongoing Federal energy R&D programs and by initiating and maintaining—by fund transfers, grants, or contracts—new energy R&D programs with private organizations. In addition, S. 1283 contemplates the establishment of Federal-industry corporations for the purpose of constructing and operating one or more full-scale, commercial-size facilities to demonstrate the technical, environmental, and economic feasibility of a particular unconventional energy technology. The result is a new Federal entity charged (1) to advance or carry out energy research and development through existing Federal department or agency programs and to initiate new Federal energy R&D programs, and (2) to establish additional energy R&D entities empowered to conduct research and development programs through the creation of Federal-industry corporations.

This multilayer and disparate structuring of energy research and development activities will result, in my view, in further and counter-productive diffusion of responsibility and will dissipate the ability to control or direct energy R&D programs from both a fiscal and policy standpoint. The potential under S. 1283 for decentralization and fragmentation of energy research and development efforts would appear to compound the present deficiencies of the existing Federal structure.

In my opinion, the appropriate organizational path to follow to pursue effectively a broadly based energy research and development effort is one which is built upon greater centralization of responsibility, not less. I believe that S. 2744—which utilizes established research and development capabilities and proven organizational structures—is better designed to achieve the goal sought by both bills.

Sincerely,

DIXY LEE RAY,
Chairman.

Senator RIBICOFF. Senator Nunn.

Senator NUNN. I have a few more questions I would like to ask Mr. Zarb since it is my understanding you are in charge of trying to get such manpower over to Admiral Reich's organization so that he can operate.

Mr. ZARB. Yes, Senator, that is correct.

PERSONNEL SHORTAGE IN REGIONAL OFFICES

Senator NUNN. What is your present personnel shortage in the regional offices?

Mr. ZARB. As of Friday night, Senator, we were one-third staffed to the extent that we think we ultimately need to be staffed. That is an average number across the country. In Chicago we are fully staffed, in some other areas we haven't done quite as well.

Senator NUNN. What specific steps are you taking in this regard at the present time?

Mr. ZARB. As I outlined earlier, whereas some OMB personnel will be assisting the Office of Petroleum Allocation people in constructing their organization they will also act as coordinators within the Federal family to insure two things: First, that we are able to obtain quickly on detail those personnel that are required. Second, there is a quality control aspect to that process, whereas we ask for specific kinds of people by grade and quality, and we make sure they report for work promptly and are there for as long as we need them which is as long as we need to recruit permanent personnel.

Senator NUNN. Are you tapping other agencies of the Government for these personnel?

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Mr. ZARB. The entire Federal Government is participating, yes, sir.

Senator NUNN. What kind of time table do you have to fill in the other two-thirds?

Mr. ZARB. I have had a conference called with our people who are in the field last evening. I gave them 2 weeks to be fully staffed and that, of course, means primarily the detailees, and the director has asked the Cabinet department heads to insure that we get maximum cooperation and, I must say, we are at this point getting substantial cooperation.

Senator NUNN. It is my understanding when the program came into effect, it was approximately 2 weeks before there were any forms available in the State and regional offices and most of the allocations were held up because they had no forms from OMB. Is that being corrected?

Mr. ZARB. I am sorry, sir.

Senator NUNN. Forms, actual forms for applications?

Mr. ZARB. I would not be able to comment on that at this particular point in time. I can tell you since we came into the situation something over 1 week ago we have provided for a technician from OMB to be on site. With this group here in Washington, approval takes place as the form passes his desk so there is no formal OMB holdup.

INPUT AT STATE AND LOCAL LEVEL

Senator NUNN. One point that was made last week by the Governors and their staffs which I thought was a valid point, was the fact they are being called on now in many respects to help apportion the shortages but they are not being given a chance to get involved in the policy decisions that are initiated. They feel there is an effort here to give them the burden, the unpleasant task of choosing between priorities all of which are important, and yet they are not being given any input whatsoever in the policymaking council. Would you like to comment on that and do you have any plans on that?

Mr. ZARB. Yes, Senator, and in any program that moves swiftly, the good process of consultation is made more difficult. However, the new Federal Energy Administration envisions many of these relationships to be developed within the Operations and Compliance Division which would include the OPA function, and also State and local government relations. Its major function will be to insure that Governors and other local elected officials are consulted during the regulation making process and then of course later during the implementation process.

Second, during this last weekend I worked with Mr. Simon in getting his new program structured. We talked with the Governors' Conference and with the Governor in charge of the Committee for the Governors' Conference, and agreed that Mr. Simon would meet with the Governors when they are in town on the 13th to go over a full range of anticipated programs and obtain their counsel.

PETROLEUM SHORTFALL

Senator NUNN. I have two questions for Mr. Ash and Dr. Ray. The testimony we have had so far is we have a 17-percent shortfall.

There was a report in the press attributed to sources in the Commerce Department, that there may be as much as a 35-percent shortfall.

Would you like to comment on that or is there any update of this information?

Mr. Ash. I will make one comment which may not be sufficient and see where we shall be. The 17-percent shortfall relates to shortfall of our petroleum resources available not our total energy resources available, although many people have confused those two, and our energy shortfall is in effect 7-plus percent. That doesn't mean that we can quickly rearrange it all but at least we need to look at it in that dimension.

Now, that number of 17 percent on petroleum resources relates to an average of 2½ million barrels a day shortfall in the first quarter of 1974, and thereafter. The fourth quarter of 1973 was much less. The first quarter of 1974 could be a bit more, so that the 17 percent is taking a 6-months period the one starting October 1 last and running up through March 30.

I don't know what higher figure they have in mind but they may be attempting to calibrate the first quarter of calendar year 1974 which, according to our plans, will be a little more than the average but I doubt if it is the number they have stated. I would have to know what they define it to be. But the 17 percent itself varies by quarter.

Senator Nunn. So the 17 percent is overall, and is an average and is not the amount of shortfall?

Mr. Ash. That is right.

On the other hand, we have had a more favorable result during the first 2 months of this last quarter of 1973 than we had expected so the average now looks like it might even be revised downward a little bit.

Senator Nunn. What would be your estimate of the latest figures of the first quarter's maximum shortfall?

Mr. Ash. The first quarter, and again talking about petroleum products in total, was estimated to have a shortfall of 3.5 or 3.4 million or so barrels a day, and that 3.4 million barrels a day is about a 20-percent shortfall of the 17 or 18 or a little less than 20-percent shortfall in the first quarter.

Now, maybe one of the numbers the Commerce Department is talking about was a particular kind of fuel. Residual fuel oil will probably have a greater shortfall than other forms. So it may be that they picked out a particular one, and it is necessary that we give special attention to the availability of residual fuel oil that serves industry and utilities in this first quarter because, as you know, we had been importing a fair amount of residual oil. We don't import that much gasoline at all. So there is a difference between the different component elements of a barrel of crude that they may have had in mind when they were quoting a particular number. I would have to know how it was defined to be able to be more responsive.

DISTRIBUTORSHIPS BEING FORCED TO CLOSE

Senator Nunn. This might not be a question that is within your purview at the moment but we are getting an awful lot of notices that distributorships that have been in existence for 20 and 30 years are now being given 30 days' notice and terminated by the major oil companies throughout our State. In other words, the man who has

been a distributor for years is just being given his walking papers with a 30-day notice.

Do you have any analysis of whether this violates any law or regulation that is now on the books, and if you do not know that answer I would certainly understand you if you supply it for the record.

Mr. ASH. Let me supply the answer, I don't know it, or you may be able next Thursday to get it from Secretary Simon, either way you choose, I can either supply it or you can get it.

Senator NUNN. It is a very serious problem because, in effect, the allocation program, as I understand it, would require that the customers at least be served and it seems to me this is a grave threat to customers. This is happening in rural areas and it will cause special hardships for farmers and other rural consumers.

Mr. ASH. It is my understanding that all of the policy work that I participated in, and I don't know the specifics of individual application of this policy, but in the policy work we have concluded that we want to preserve the distribution system, meaning all the independents and others that are part of the distribution system.

Now maybe someplace between that policy, that goal, there have been some actual problems in implementation, I don't know those. Certainly we believe that it is fundamental to preserve our distribution system.

Senator NUNN. I would appreciate very much a letter to that effect to me because I think it should be passed on to some of the major oil companies who are closing out distributorships right and left.

Mr. ASH. I will furnish then for the record a statement very explicitly to that question you have asked me.

[The above-referred-to information follows:]

ACTION TO ASSIST THE INDEPENDENT PETROLEUM INDUSTRY

Both the independent refineries and the independent fuel distributors require additional fuel and are encountering serious problems in obtaining such supplies during the current shortage.

While the Federal Energy Office may be unable to resolve all such problems, it can and does guarantee that all companies will be treated fairly under FEO programs. In the case of oil refineries, FEO will mandate the transfer of crude supplies from companies having abundant inventories to refineries having little or no inventories. These actions are being taken in accordance with regulations that contain stringent sanctions for cases of non-compliance.

In the case of independent fuel distributorships, FEO has requested the major oil companies to make available lower cost domestic supplies to independent distributors who would otherwise be forced to obtain the products refined from the higher cost imported crude. If these measures are not sufficient to assist the independent distributors, FEO is willing and able to take stronger action.

Senator RIBICOFF. Senator Percy.

Senator PERCY. I would like to pick up where we left off and give Commissioner Doub a chance to respond to this New York Times editorial and his own quotation in it. I would ask unanimous consent that the entire editorial be placed in the record at this point.

Senator RIBICOFF. Without objection.

[The above-referred-to editorial follows:]

NUCLEAR POWER DILEMMA

Among the alternative sources of energy for the future, what once seemed the most promising seems to be becoming one of the more problematic.

At a time of energy crisis, when the backers of nuclear power hoped to be riding confidently on a momentum of past successes and future promise, the industry is

plagued by bottlenecks and frustrations. Even worse for nuclear advocates, only a small part of the shortfalls can be attributed to the favorite bogeys, government regulation and interference by environmentalists. Serious problems in nuclear power generation arise from the economics and technologies of the industry itself.

President Nixon sounded an ostensibly positive note in his energy statement earlier in the month when he asked the Atomic Energy Commission "to speed up the licensing and construction of nuclear plants," as if bureaucratic red-tape and environmental challenges were the central problem.

It was left to Commissioner William O. Doub of the A.E.C. to enunciate the realities to a recent gathering of nuclear power executives. At the thirteen most critical nuclear plants now under construction, Mr. Doub said, "discussions with utility management produced the consensus that no significant acceleration of construction programs was possible," for entirely economic reasons. The Federal Power Commission analyzed construction delays in the 28 nuclear plants that were scheduled to become operational this year and found that 32 plant/months of delay had been caused by public lawsuits or changes in regulatory requirements, but 229 plant/months of work—*seven times as many*—had been lost through low labor productivity and shortages, late deliveries or breakdowns of components and similar economic or technological failures.

Among plants already functioning, breakdowns and malfunctions are routine. All except one of New England's five large nuclear plants are now operating at fractions of their intended capacity, and one of these has been inoperable for ten of the last twelve months. Both of Consolidated Edison's nuclear plants at Indian Point are out of service, and there is no certainty when either will operate again.

Power generation by the esoteric process of nuclear fusion—if it can be realized—remains a lively, perhaps the best, hope. But the fission reactors of today, on which so much of tomorrow's hopes had been hung, have generated more dismay than power—and this is so, even ignoring the strenuous concerns for nuclear safety which have multiplied among scientists in and out of the A.E.C., but which the industry continues to minimize.

The arguments are becoming ever more persuasive that the nation should lean more toward coal, solar and geothermal processes and nuclear fusion to meet its energy needs a decade or more hence and plan today's research and investment accordingly. Little is gained by replacing a politically unreliable fuel—oil—with technically unreliable and potentially dangerous power from nuclear fission.

Mr. Doub. Senator Percy, the short answer in the Times editorial correctly quoted me.

Senator Percy. I am sorry, I didn't hear you.

CONSTRUCTION PROBLEMS WITH NUCLEAR POWERPLANTS

Mr. Doub. The short answer is the Times editorial is correct. The fact of the matter is in trying to come to grips with the construction problems and the stretching out that we have seen, and in the context of the energency situation in the country, we did contact certain companies which are presently building nuclear powerplants. Presently there are 59 plants being built which have been all through the environmental and safety review, they have had their public hearings, they have been granted a construction permit, and the licensing at that stage, as opposed to the operating licensing phase, has ended. They are now pouring concrete. So we thought it was completely appropriate to contact owners of 13 plants whose power supply has been deemed critical by the Federal Power Commission with regard to why has the time been stretching out so much and what can be done. It was their thought that little could be done in the immediate future.

However, we have identified some of the problems, and while they are not particularly optimistic, I would be somewhat more optimistic. The fact is that with a burgeoning nuclear industry we have shortages of welders, pipefitters, electricians. We don't have

enough qualified people. The architect engineers who design and build the units are stretched thin. Something can be done about that and alternatives are being looked at. Various departments of the Government have been asked to feed in proposals to the administration, and we are in the process of coming to grips with some proposals that we are going to make.

Just to put it in context, the fossil fuel plants that are being constructed in this country have also been extended timewise. While it still takes a nuclear plant about 25 percent longer to be constructed, fossil fuel plants take about 25 percent longer to construct now than it did a couple of years ago. So it is a general problem.

Senator PERCY. Then do you concur with the conclusion of the editorial, that:

> The arguments are becoming even more persuasive that the nation should lean more toward coal, solar and geothermal processes and nuclear fusion to meet its energy needs a decade or more hence and plan today's research and investment accordingly. Little is gained by replacing a politically unreliable fuel—oil—with technically unreliable and potentially dangerous power from nuclear fission.

Mr. DOUB. I didn't agree with that.

Senator PERCY. I wanted to be sure when you said at the outset you agreed with this editorial that on the record you were not concurring with the whole thing.

Mr. DOUB. No. I agree with that sentence that 13 utilities executives said that little or nothing can be done to——

Senator PERCY. In other words you agree with that sentence that is attributed to you in the quotation?

Mr. DOUB. That is correct; and nothing further.

Senator PERCY. That is a more limited endorsement I would say. Mr. Ash, are you coming back on Thursday?

Mr. ASH. I think that is right; yes, I will be here Thursday.

SHORTCOMINGS OF S. 2744

Senator PERCY. All right. Even though Senator Jackson is not here now because of another pressing engagement, he did give a statement. I think you should have a chance in the same forum to answer a few of the shortcomings that he mentioned to the bill. He said, for instance:

> The bill which we are considering today to create an independent energy and R. & D. Administration, ERDA, cannot serve either of the functions which are needed, first it does not contain the research strategy, objectives, budget goals and grants of new authority which are so urgently required to get a comprehensive nonnuclear research program underway.

Would you care to comment on that first objection he has?

Mr. ASH. I would just say I think it does contain all of that which he has described as not containing. We may have a misunderstanding that we can clear up on Thursday but it is certainly my perception that it contains exactly that.

Senator PERCY. I understand Senator Jackson will be here on Thursday, but in the same forum today as he made his statement, would you care to comment on his conclusion that:

> It does not provide an adequate permanent organization which is appropriately related to other Federal responsibilities for energy.

Mr. ASH. I would say it provides, as I see it, the best possible adequate permanent organization that not only relates to other

agencies but more importantly relates to the very subject of energy research and development itself by having that function within the confines of the entity that would be created by the ERDA legislation.

STATUTORY BASIS FOR CREATION OF FEA BY EXECUTIVE ORDER

Senator PERCY. In the several conversations I have had this weekend with the White House and with Secretary Simon, I have assured them that we would do everything we can do to give adequate authority and to move ahead with the greatest dispatch, taking into account the circumstances. But I wonder if you could comment, Mr. Ash, on the legal underpinnings for the Executive order to create FEA. As a nonlawyer, it does seem a little thin to me, and I want to be certain that these hearings give the administration a chance to put on record the fact that they do have an adequate statutory basis for creating the agency by Executive order in advance of the legislation.

Mr. BINGMAN. I think, Senator Percy, that what is being done in an interim way rests on the number of statutes which are already in existence which vests powers in the President which will now be delegated to Mr. Simon as Administrator and acting in this interval before formal legislation can be advanced and approved by Congress, and the citations which have been placed in the Executive order refer to the Emergency Petroleum Act of 1973, the Defense Production Act of 1950 and section 203(a)(3) of the Economic Stabilization Act of 1970.

Admittedly in the citation of these statutes one must now go to these statutes to see the particular authorities which have been vested by the Congress in the President which are now being delegated here.

Senator PERCY. I think it would help us immensely if you could put your staff to work to amplify the record on these points. Maybe they have done it already.

Mr. BINGMAN. Yes, sir.

Senator PERCY. To be certain that what is being done has good statutory basis, if you would like to supplement that, Mr. Chairman, again I would ask unanimous consent that the record be held open for as many days as you require?

Mr. BINGMAN. I think by the end of the week would be all right.

Senator RIBICOFF. Without objection.

[The information referred to follows:]

ESTABLISHMENT OF FEDERAL ENERGY OFFICE

Executive Order No. 11748 of December 4, 1973, established the Federal Energy Office in the Executive Office of the President.

The authorities in the Order are based on the powers vested in the President by several statutes, including the Economic Stabilization Act of 1970 (P.L. 91–379, 84 Stat. 798), as amended; the Emergency Petroleum Allocation Act of 1973 (P.L. 93–159); the Defense Production Act of 1950 (50 U.S.C., App. 2061, *et seq*), as amended; and Section 301 of title 3 of the United States Code.

The Order provides as follows:

Section 1 established the Office under the immediate supervision and direction of an Administrator and a Deputy Administrator. It also stated that the Administrator shall be the Deputy Secretary of the Treasury.

Section 2 stated that the Administrator shall advise the President on domestic and foreign policies relating to the production, conservation, use, control, distribution, and allocation of energy and on all other energy matters.

Section 3(a) delegated to the Administrator all of the authority vested in the President by the Emergency Petroleum Act of 1973. This Act authorized and required the President to allocate oil, residual fuel oil, and refined petroleum products to deal with existing or imminent shortages and dislocations in the national distribution system which jeopardize the public health, safety, or welfare.

Section 3(b) directs the Administrator either to submit to the Congress the reports required by Section 4 (c)(2) of the Emergency Petroleum Act, or empowers the Administrator to require any other officer, department, or agency to submit the report to Congress. These reports deal with changes after 1972 in the aggregate share of branded and non-branded independent marketers and other persons engaged in the marketing and distributing of refined petroleum products.

Section 4(a) delegates to the Administrator the authority vested in the President by Section 203(a)(3) of the Economic Stabilization Act of 1970, as amended. This section deals with establishing priorities of use and systematic allocation of supplies of petroleum products including crude oil in order to meet the essential needs of various sections of the Nation and to prevent anti-competitive effect resulting from shortages of such products.

Section 4(b) directs the Chairman of the Cost of Living Council to delegate to the Administrator of FEO such authority under the Economic Stabilization Act as may be necessary to carry out the purposes of that Act as it relates to energy matters. This involves the pricing controls over petroleum and petroleum fuel products that are administered by the Energy Division of the COLC.

Section 5 delegates to the Administrator the authority vested in the President by the Defense Production Act of 1950, as amended, as it related to the production, conservation, use, control, distribution, and allocation of energy. It also suspends any provision of Executive Order 10480, as amended, which is inconsistent with the authorities delegated by Section 5 for so long as that Section remains in effect. Executive Order 10480 concerns the administration of the Defense Mobilization Program and the coordination of executive branch activities dealing with production, procurement, manpower, stabilization, and transport.

Section 6 provided that Executive Order No. 11726 of June 29, 1973, which established the Energy Policy Office, is superseded to the extent it is inconsistent with this Order.

Sections 7, 8, and 9 are principally administrative in nature.

TIME LIMITATION ON NEW AGENCY

Senator Percy. Mr. Ash, do we look upon FEA as a temporary step so we do not lose sight of the need for broader reform and consolidation through DENR? And is there any time limitation put on FEA, so we at least have a goal toward which to work in having a more permanent organization established in law?

Mr. Ash. Senator Percy, I think that also is a matter that I think would be very useful to get on the record at this time. Certainly we have an immediate crisis in front of us and must respond to it in all the possible ways that we can. Hopefully that crisis will lose some of its crisis dimensions as time goes by and it is our contemplation that the functions that would here be within the Federal Energy Administration would ultimately be an integral part of the proposed Department of Energy and Natural Resources when things are more normalized. Rather than wait for the DENR legislation, given the crisis nature of the problem, we feel we should move at this time. The legislation will probably propose a 2-year time recognizing that specific fact that you have mentioned.

Senator Percy. The reasons that I will be quite insistent on this aspect of it is that I think in this case haste will make waste. We have seen in the special prosecutor problem, and in the new Attorney General appointment made in such haste that we didn't even realize there was a constitutional question as to the Attorney General, that

in the end we really consumed a great deal of energy and time and effort by not looking to be absolutely certain that what we were doing was appropriate. So we will try to watch that checkpoint, but will work together, recognizing the emergency which all of us regret deeply. We will try to work just as expeditiously as possible, but still have sound footing each step of the way. It would be horrendous to have a new Administrator set up and putting out a lot of directives and then have them all declared unconstitutional or illegal. That would just add further confusion to the already confusing problems.

I have no further questions at this time. I want to thank the witnesses very much indeed for being with us this morning.

Senator RIBICOFF. I want to thank both of you and your staffs.

The committee will stand in recess until 2 o'clock.

[Whereupon, at 12:35 p.m., the committee was recessed until 2 p.m. the same day.]

AFTERNOON SESSION

Senator RIBICOFF. The committee will be in order.

Our first witness is Mr. Charles A. Robinson, corporate counsel, of the National Rural Electric Cooperative Association.

TESTIMONY OF CHARLES A. ROBINSON, JR., CORPORATE COUNSEL, NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION, ACCOMPANIED BY JOSEPH S. IVES, ENVIRONMENTAL SCIENTIST, AND BRADLEY KOCH, STAFF ENGINEER, RURAL ELECTRIC COOPERATIVE ASSOCIATION

Mr. ROBINSON. Mr. Chairman, my name is Charles A. Robinson. I am the corporate counsel of the National Rural Electric Cooperative Association which we now refer to as NRECA.

I am accompanied by our environmental scientist, Joseph S. Ives, and our staff engineer, Mr. Bradley Koch. We very much appreciate the opportunity to appear before the subcommittee on this very important matter of consolidating government energy-related research activities.

If our statement can be included in the record in full, we will be happy to merely summarize it orally.

Senator RIBICOFF. Without objection, the entire statement will go into the record as if read.

[Mr. Robinscn's statement in full follows:]

STATEMENT OF CHARLES A. ROBINSON, JR., CORPORATE COUNSEL, NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION

Mr. Chairman, and Members of the Subcommittee: My name is Charles A. Robinson, Jr. I am the Corporate Counsel of the National Rural Electric Cooperative Association (NRECA). NRECA is the national service organization of consumer owned cooperatives which provide electric utility service to some 24 million consumers located largely in the sparsely populated agricultural areas of 46 states. I am accompanied by Mr. Joseph S. Ives, our environmental scientist.

For several years, many of us in the electric utility industry and in other energy related industries, as well as knowledgeable members of both houses of the Congress, have been warning of an impending shortage of the raw materials upon which our energy intensive economy is completely dependent. The "energy crunch" is now upon us, and it is indeed our most serious domestic problem.

Moreover, as matters have developed, it is also one of our most serious problems of foreign policy. We cannot tie our nation's energy future to the vagaries of international politics.

For several years NRECA has advocated a sharply stepped up Federal role in energy research. Our membership has participated in the development of the Electric Power Research Institute (EPRI), and rural electric systems are now beginning to commit substantial funds to EPRI programs. However, we also believe that the magnitude of the energy research burden imposed on us by the present situation requires a truly massive effort; an effort which cannot succeed without strong and thoroughly coordinated Federal leadership. We offer our support of S. 2744, because it is clearly designed to improve the coordination of Federal research activity. It may not yet be perfect in every detail, but it is very soundly conceived legislation. It anticipates the need for increased Federal R & D activity and set in motion the machinery to handle the work.

S. 2744, by divorcing the R & D activity of the Atomic Energy Commission from its regulatory function, should also help to allay the fears of persons who have felt that the combined research and regulatory functions of AEC might somehow downgrade nuclear safety or environmental standards. We do not share these fears, but we do not object to the separation proposed.

As we interpret Sections 103(6) and 108(a) of S. 2744, they would permit ERDA to participate in and help fund EPRI projects, and thereby speed electric industry research. We feel that these provisions are excellent from the industry's standpoint.

As we understand, however, S. 2744 would not actually authorize any additional research programs, and we really believe that if the potential of this new agency (ERDA) is to be realized, S. 2744 must be followed by legislation which does strengthen and broaden the substance of Federal research activity. S. 1283, introduced by Senator Jackson and others, is one example of the kind of legislation which we feel is needed.

Actually, the U.S. energy crunch is primarily a shortage of petroleum based liquid and gaseous fuels upon which we depend for 78% of our energy. What we must do, in my opinion, is shift our energy base away from natural petroleum and toward coal, shale and nuclear fuel, all of which we have in abundance, assuming we develop a successful breeder type nuclear reactor.

This changeover is, the way we see it, as much of a problem of business economics and development as it is one of pure research. Therefore, we feel strongly that it may be time for the Federal government to set some quantitative and time certain objectives for synthetic liquid fuel production. Many utilities are now facing fuel oil prices of $7 per barrel; some prices are even higher. Scientists with whom we have recently discussed the process, advise us that synthetic liquid fuels can be produced from coal or from shale at about that price. They are of the opinion that it would require ten years of construction and planning time to produce synthetic liquid fuel in quantities equal to about 10% of total U.S. liquid fuel demand. We feel that substantial synthetic liquid fuel capability is essential to the future economic strength and national security of the country; even to the extent of government participation in actual construction and operation of full scale production facilities if necessary, or government support of synthetic liquid fuel prices. Under even the most optimistic estimates, our natural petroleum reserves cannot last more than several decades. We cannot achieve energy "self-sufficiency" without immediate attention to developing substantial synthetic fuel capability.

NRECA has traditionally supported the concept of a national power grid; complete interconnection of all major electric generation and all major load centers in the country. This is one way to help shift our fuel consumption toward those areas where coal is predominant, and away from oil and gas. We suggest that ERDA is the vehicle through which to develop plans for a national grid system.

Subsection 104(d) of S. 2744 (page 9) transfers to ERDA certain research functions of the Environmental Protection Agency which relate to developing alternate automotive power systems and stationary power plant emission control technology. This is in our view an excellent concept, but we urge that Subsection 104(d) be expanded to include the transfer to ERDA of EPA research activities which form the bases for that agency's power plant performance standards.

It seems to us that at least on some occasions the policies of government agencies responsible for energy availability work in opposition to the policies of those agencies responsible for environmental protection. We believe that combining in one agency the research base for both energy production, and the environmental

protection standards which such production must satisfy, would be an enormous step toward a coordinated Federal policy on the seemingly opposed objectives of adequate energy and environmental protection.

In summary:

(1) We support S. 2744 as a vehicle which can strengthen Federal energy research, coordinate government research with the work of the Electric Power Research Institute, and quiet fears which have been voiced against the combined research and regulatory functions of the Atomic Energy Commission.

(2) We caution, however, that a reorganization of functions will not itself produce substantial additional R & D effort or make much progress in solving the energy "crunch" unless Congress gives the new agency greatly expanded and broadened authority and funding. We urge consideration of substantive research on a scale contemplated by Senator Jackson's bill (S. 1283). We suggest special emphasis on synthetic liquid fuel production capability even to the extent of Government support for product prices, or Government participation in construction and operation of full scale plant facilities.

(3) We suggest that Section 104(d) of S. 2744 (page 9) be changed to include the transfer to ERDA of EPA research used to develop power plant environmental protection standards. This change would, in our view, constitute a major step toward reconciliation of the government's divergent policies on energy development and environmental protection.

(4) We continue to support the concept of a national power grid, with the added justification of moving toward coal and away from gas and oil for electric power generation.

We very sincerely appreciate this opportunity to present our views to the Subcommittee, and wish it much success in moving toward a solution of the energy shortage.

Senator Ribicoff. Please proceed.

Mr. Robinson. Thank you, Mr. Chairman.

NRECA SERVES 46 STATES

NRECA is the national service organization of REA financed electric systems. We serve about 25 million people in the largely rural agricultural areas of some 46 States. We generate some of our own power, but most of the power which we distribute to our consumers, is purchased from power companies, the Federal Government, and State-owned power facilities.

We support S. 2744 as a vehicle which can strengthen Federal energy research, coordinate Government research with the Electric Power Research Institute in which we also participate, and quiet fears which have been voiced against the combined research and regulatory functions of the Atomic Energy Commission.

We do not share the fears which have been voiced by some groups with respect to the combined functions of the AEC, but we recognize their existence, however, and believe that this bill should help to quell those fears.

We caution, however, that a reorganization of functions alone, will not, of itself, produce substantial additional research and development effort, or make much progress in solving the energy problem, unless Congress gives the new agency greatly expanded and broadened authority and funding.

We urge consideration of substantive research on a scale contemplated by Senator Jackson's bill, S. 1283, and suggest that special emphasis be placed on synthetic fuel capability, even to the extent of government support for product prices or government participation in construction and operation of full scale synthetic fuel plant facilities.

As the chairman is well aware, the present crunch is largely caused by a shortage of petroleum products. And, in view of the fact that our present consumption of petroleum is on the order of 6 to 6½

billion barrels a year, when we are producing something just over 4 billion barrels ourselves, quite obviously any petroleum which you use in the future beyond our present consumption, must be imported.

We would point out, Mr. Chairman, that petroleum is now costing on the order of $7 per barrel and that synthesized petroleum from coal and shale can be produced for about that price. We think it is extremely important that whatever activities this new agency engages in, include heavy emphasis on the development of, as fast as possible, a synthetic fuel capability for the United States.

We also suggest, Mr. Chairman, that section 104(d) of S. 2744, on page 9, be changed to include the transfer to the ERDA of research presently performed by the Environmental Protection Agency and used to develop powerplant environmental protection standards.

It seems to us that if we are going to set up ERDA as an energy agency, and if we are going to further consolidate the energy development and the energy production activities of the Federal Government, there must be included in this overall administrative machinery, some means of coordinating our environmental protection policies, because we feel that we cannot develop an adequate energy base in this country and continue to provide adequate electricity and adequate energy for our people, unless we do coordinate the parallel objectives and the policies used to achieve these objectives; namely, adequate energy and environmental protection.

If we allow these two to go on independent courses, as they seem to be proceeding at the moment, it seems to us it is going to be extremely difficult to achieve energy self-sufficiency.

SUPPORT A NATIONAL GRID SYSTEM

We continue to support the concept of a national power grid, with the added justification now of moving toward coal and away from gas for electric generation. If we can concentrate a lot of our electric power generation, in coal-rich areas, and transmit that power over high-voltage facilities to those areas where coal is not abundant—where we are presently dependent on oil, this is one way of helping us to switch from our present energy economy, based largely on petroleum and natural gas and oil, to one based on nuclear fuel and on coal, which is our hope for the future.

We must shift from an oil based energy system to a system based on nuclear fuels and coal.

Mr. Chairman, we very sincerely appreciate the opportunity to present our views to the subcommittee and we most certainly wish you much success in dealing with the energy shortage.

ABOUT 26 MILLION PEOPLE SERVED BY NRECA

Senator RIBICOFF. May I ask a few questions? How many people in this country are served by NRECA?

Mr. ROBINSON. We serve about 26 million people.

Senator RIBICOFF. And in how many States are you located?

Mr. ROBINSON. 46 States.

TIMETABLE FOR DEVELOPMENT OF SYNTHETIC FUELS

Senator RIBICOFF. How long do you think it would take to really bring synthetic fuels to large-scale usage or production?

Mr. Robinson. It is not a short term solution, Mr. Chairman. We have talked with people, scientists from the major energy corporations—I might mention Westinghouse, in particular—and they tell us that liquid fuel and synthetic natural gas can be produced from coal with known technology and that perhaps a 10 percent impact on the demand could be available within a 10-year period.

Senator Ribicoff. Let me ask you, from where you sit in your responsibilities, what do you see the shortfall of electric energy that you would be in a position to supply your customers, say, a year from now?

NEW PLANTS ARE COAL FIRED

Mr. Robinson. It is going to be very difficult, Mr. Chairman. Most of the new plants that our people are putting on the line are coal fired, largely lignite fired, and that is why we take such a great interest in the surface mine control legislation. We are building a number of plants in the Colorado, North Dakota, Wyoming area. They are under construction and on the drawing boards. These are all coal-fired plants. Our people, with very few exceptions, one exception in Texas where there is some natural gas to be found, are unable to obtain natural gases for their fuel, even for existing plants.

They are attempting to switch to distillate fuel and obviously there is not going to be as much middle distillate fuel, that is heating oil No. 2, there is not going to be very much of that available, certainly not enough available to go around in the immediate future. And it looks to us that unless the utility industry is given a rather high priority on the availability of petroleum fuels, we are going to find it very difficult to meet loads where we are, depending on petroleum-based fuels.

I think it is going to be very difficult.

Senator Ribicoff. Well thank you very much. I appreciate you coming here, you represent an important segment of this Nation and it is very important to get your position.

But generally, you support ERDA and its creation?

Mr. Robinson. Yes, we support it and we also—a mere reorganization is not going to achieve a great deal more research and we support Senator Jackson's broadened research proposals.

Senator Ribicoff. Well thank you very much, gentlemen.

Mr. Robinson. We appreciate the opportunity to testify.

Senator Ribicoff. The next two witnesses will be Mr. Alvin Weinberg, Director of Oak Ridge National Laboratory, and Peter Auer, professor at Cornell University.

I appreciate both of you gentlemen coming here. You are very distinguished, knowledgeable people in this field. So, will you gentlemen proceed as you will, one or the other, you determine who will go first.

TESTIMONY OF ALVIN WEINBERG, DIRECTOR, OAK RIDGE NATIONAL LABORATORY, AND PROF. PETER AUER, CORNELL UNIVERSITY

Mr. Weinberg. I have a short statement. I am the Director of the Oak Ridge National Laboratory. I have been somewhat involved in the current exercise on the $11 billion R. & D. initiative and I might mention that Professor Auer has been more centrally involved in helping prepare the report.

I am grateful for this opportunity to speak in favor of the ERDA bill. Since previous witnesses have talked about the administrative details, I will confine my remarks to two basic questions:

First, an analysis of what the primary goals for ERDA and energy research ought to be; and second, is the proposed structure of ERDA adequate to achieve these goals?

I am submitting, for the record, a position paper entitled "A Strategy for Energy Research and Development" that Calvin Burwell of the Oak Ridge National Laboratory and I have prepared.

[See appendix, p. 539]

Mr. WEINBERG. This is a very personal attempt, in the few months that I have been thinking broadly about these problems, to see just how one can visualize an energy R. & D. strategy; more particularly, how can you make energy R. & D. strategy follow from an overall energy policy?

SELF-SUFFICIENCY IN ENERGY

Here I will summarize a few of the important points. By now, there is a general consensus about something called energy self-sufficiency. But there is a great deal of fuzziness about what you really mean by energy self-sufficiency. In the position paper, I said it should be interpreted as meaning that not more than 15 to 25 percent of all our oil and gas should be imported after 1985, to keep our imports at that absolute level. The basic strategy for achieving this goal is to shift from oil and gas, which we do not have, to nuclear and coal, which we do have.

Of course, we shall try to squeeze out as much oil and gas as we can from existing fields, and try to find additional fields. But it is clear that these measures will not really be sufficient and, therefore, conservation is going to be immensely important.

PROJECTING ENERGY DEMANDS FOR THE FUTURE

In this energy business, there is a game called scenario writing: People project energy demands for 1985 to 2000 and beyond. We are presently using in this country about 70,000 trillion British thermal units of energy and it is expected to go up to 125,000 trillion by 1985, according to one scenario.

But most people who study the matter feel that rate of increase is too high and that we must aim at not more than 100,000 trillion Btu's by 1985. Beyond that, the two major thrusts of our R. & D. strategy must be, as I put it, guaranteeing the validity of our coal option and guaranteeing the validity of our nuclear option. To see what this means, there are estimates that show that by 1985 we will have to be digging 1,800 million tons of coal per year, which is three times as much as we have ever dug; and 70,000 tons of uranium per year which is five times as much as we are now digging.

BEYOND 1985

As I visualize this problem from the long range viewpoint, I must say that it always strikes me as being an enormously difficult question. How are we going to go from 600 million tons of coal to 1,800 million tons of coal in 1985? Beyond 1985—which I call the long range program—people talk a great deal about exotic things like solar energy, geother-

mal, fusion. We do not have nearly the assurance about these possibilities as we do about the shorter range possibilities—coal, increased production of oil and gas—or the nuclear breeder which is a medium range possibility.

The long range possibilities must be pursued, but we must make it clear that they cannot have any impact for the next 7 to 10 years.

I will very quickly state how I feel about the first question. Can ERDA, as it is presently conceived, achieve the end of the short range program which is to validate the coal and nuclear short term options? Particularly, I have heard the concern expressed that ERDA is in good part an enlargement of the Atomic Energy Commission. Can it then be counted on to give proper emphasis and force to the short range elements of the program—conservation and increased production of oil and gas and coal, which are not nuclear?

CAN ERDA FUNCTION?

A second concern which I have heard voiced is, can ERDA which is a research agency separate from the commercial energy community, organize its research so as to be adequately responsive to the real energy problems in a real world? In other words, can the research and development of this free standing research and development agency mesh with and implement an energy policy?

My own belief is that the answer to both of these questions is yes, ERDA ought to be able to do this. As far as giving proper attention to coal, I do not see any real problem there. After all, the Office of Coal Research and the Bureau of Mines Energy Centers will have been moved into ERDA.

But there is another point here and it goes like this: If you add up the total amount that has been spent on coal research in this country in the past 20 years, it comes to barely $140 million. This is perhaps one-fifth or one-sixth the amount that has gone into a single reactor system.

So, coal research has simply suffered from fragmentation and insufficient funding. One of the characteristics of AEC is that it moves into problems massively. This massive, coherent kind of attack I believe is very much needed in the coal business.

NUCLEAR RESEARCH VERSUS RESEARCH IN OTHER SOURCES OF ENERGY

Senator RIBICOFF. Along that line, do you think that because AEC will really be the base of this agency, that the men who have worked all these years in AEC would be prejudiced, or emphasize nuclear research as against alternate sources of energy research?

Mr. WEINBERG. Well that is a possibility, but I do not really think it will present difficulties. We have had quite a bit of experience in our own laboratory with what we call "redeployment." The Oak Ridge National Laboratory over the past 10 years has redeployed around the problem of desalting the sea and over the years we have gradually acquired more and more expertise until now we have, in this National Laboratory, one of the foremost institutions that is concerned with desalting the sea. The point is that the unit processes, the individual elements of desalting the sea, are not all that different from what

goes on in parts of nuclear development. I therefore do not think that there really is much difficulty in redeploying once the problem to be solved is well defined.

I confess this is some concern, but one must remember again, that in ERDA there will be an assistant administrator essentially for fossil fuels. One of the things I have learned in my years of experience with the bureaucracies is that if you establish an office, then that office always has a tendency to expand and proliferate and become as powerful as possible. Once you establish an assistant administrator for fossil fuels, then fossil fuels will get a fair shake.

DECISION OF PRIORTIES

Senator RIBICOFF. Who do you think ought to have the responsibility to allocate the funds between the various sources or make the decision of where the priorities should drop?

Mr. WEINBERG. As the matter stands now, presumably that allocation will be made by the Administrator of ERDA and I would hope the Administrator of ERDA would have proper advice which would not be colored by a nuclear bias, I guess my own impression about it, at least in the conversations I have had with various people in the AEC and outside the AEC, is that the advice would be not prejudiced toward nuclear and that one could count on the administrator to make the proper allocations. Of course the administrator will probably be advised also by Congress, and advised by the Office of Management and Budget.

Senator RIBICOFF. Let me ask you, there is no question in my mind, there may be in yours, that the whole problem of energy sufficiency is a problem that will be with us for decades.

Mr. WEINBERG. That is right.

Senator RIBICOFF. And not only energy sufficiency for us but also, as a great Nation, we are going to have to help supply the rest of the world. Oil is a finite substance—29 years, 40 years, 50 years, 60 years it is exhausted.

COUNCIL OF ENERGY ADVISERS

Because of the importance, do you think that it would be advisable to have a council of energy advisers like the council of economic advisers, either attached to the White House, or attached to the Administrator in ERDA? Does this strike any reaction with you?

Mr. WEINBERG. I have not thought seriously about a council of energy advisers. I do happen to be a member of what was, until this morning, called Governor Love's Advisory Council on Energy R. & D. but I think on the whole, some kind of advice of that sort at an appropriate level of Government is a good idea.

Now this gets to the question which I think Professor Auer is going to speak to. Just what is the relation between ERDA, which is a research organization and energy policy, as contrasted to energy R. & D. policy; and who in this country is, in fact, going to establish energy policy as contrasted to energy R. & D. policy? A council of energy advisers could be a very good and useful thing, depending, of course, upon where in the Government this council of advisers reports. I presume that you think of it in terms of advising the President, as the Council of Economic Advisers advises the President?

Perhaps I could say something further about this question and it is related a bit to what you just raised. Would ERDA, which is a somewhat isolated agency, in fact, be able to relate to real problems in the real world? I do not think that issue is a big problem. The Atomic Energy Commission, after all, developed a civilian nuclear reactor program which has now become very much a part of the real world. I think that the same kinds of patterns that developed through the years at AEC could be carried over, say, if you tried to do the same thing with respect to some of the other modalities, particularly coal, and derivatives of coal.

With respect to the longer range program, there is much less question—I do not think anybody argues that if you are interested in things that really do not have a marketplace for 10, 15, or 20 years, then obviously the Government is the proper place to focus it. An institution like ERDA is a very appropriate sort of thing.

I guess I would simply close with one very important admonition and it goes like this. I have spent my entire career in the energy business. I have been in the nuclear field for some 30 years or so, and one of the things I have learned is that research is by and large a frustrating and long term business. I think it would be very unfortunate if the American public and the Congress got the impression that the establishment of ERDA, of and by itself, is going to solve the problem of short term energy shortages. It just is not. Whether there are any technological resolutions to that problem is a difficult question that has to be addressed very seriously.

Senator RIBICOFF. From where you sit, with your knowledge, do you feel that coal would be the quickest source of alternate supply of energy?

OIL FROM SHALE FOR THE SHORT TERM

Mr. WEINBERG. No, I think from where I sit, oil from shale would be the quickest source.

Senator RIBICOFF. Oil from shale, you feel, could be developed faster?

Mr. WEINBERG. Well, both schemes can be developed at a price; but my impression is that oil from shale is a good deal cheaper with the existing technology than oil from coal or gas from coal.

Senator RIBICOFF. Which substance to have oil extracted from would have the least consequences in the environmental issue?

Mr. Weinberg. Probably coal, but one must be careful there because that assumes that you can reclaim the stripped land, because most of the coal will probably be Western coal. But I point out as far as oil from shale is concerned, in Estonia right now they are using shale oil commercially.

In Brazil, there is a plant using oil from shale, so that is technology that really is here. It is a question of how expensive it is. The Office of Science and Technology estimated (some 2 years ago) that you could get oil from shale at about $6 a barrel. At the time, this seemed like an awful lot, but now it does not seem like very much.

Senator RIBICOFF. So, what was uneconomic up until 6 months ago, is now economic because you have got oil at $8 and you read in the paper where certain types of oil went up to $14 to $15 a barrel. So, I suppose $6 to $8 a barrel becomes economic.

Mr. WEINBERG. That is right. The South African Synthetic Oil, Ltd., has been producing quite a bit of oil as well as gas from coal.

They sit right on top of a coal mine and the coal is very cheap. It can be done, but it is expensive. There is this point, and I want to stress it, that the question of ERDA is rather separate from the question of self-sufficiency by say 1980. And Congress must understand that and the public must understand, if indeed your aim is to achieve self-sufficiency by 1980, then you are committing yourself to something that in my view is very, very much more than ERDA. I believe that may make a fair amount of sense: to commit ourselves to something very much more than ERDA.

SELF-SUFFICIENCY IN ENERGY BY 1980

Senator RIBICOFF. Well that is very important. What would be the alternative to ERDA that could give you a measure of self-sufficiency by 1980? What would you have to do to achieve that?

Mr. WEINBERG. Well, that is tough; I prefer not to refer to this as an alternative to ERDA because I think we need ERDA.

Senator RIBICOFF. All right then, in addition to ERDA?

Mr. WEINBERG. In addition to ERDA? There is a possibility.

Senator RIBICOFF. Professor Auer, you can interject and interrupt whenever you want to.

Mr. AUER. Well, I though at an appropriate place I could start off.

Senator RIBICOFF. I am anxious to get the answer to that.

Mr. WEINBERG. Well, this idea—actually I think Peter Auer originated it—is to launch a very large crash program to produce oil from shale and gas from coal in much the same way we produced synthetic rubber during World War II, or established the War Administration for Petroleum Production. It probably is possible by 1980, to extract maybe 2 million barrels a day of oil from shale and to produce an equivalent amount of gas from coal.

The gas from coal will be rather more expensive than the oil from shale. The cost of the whole crash program would be on the order of between $30 and $50 billion.

Senator RIBICOFF. All right, what would you have to do to achieve this? What, in addition to ERDA, must you do to achieve what you are saying?

Mr. WEINBERG. I think the Congress would have to decide, and the administration would have to decide, this is a good idea.

Senator RIBICOFF. All right, but if it would bring the results, what would you have to do to achieve it?

MOBILIZATION OF INDUSTRY

Mr. WEINBERG. Well you would mobilize the oil industry. You would mobilize the chemical industry. It would be a grand mobilization. And let me say, Senator, that it seems to me there is a certain kind of economic advantage to such an approach. Because if, indeed, the energy crunch is going to throw us into a depression, then injecting $50 billion into the economy for something that could very well be a great thing might have a very good effect in counterbalancing the economic consequences of the energy shortage.

Senator RIBICOFF. Well do we have the facilities, the technology, both in equipment and manpower, to do that in this country?

Mr. WEINBERG. I think we do.

Senator RIBICOFF. Well, I think this all is important. It is an alternative that you make the Congress and the people to face up to. If this is what you mean, the worst thing we could do is kid ourselves.

Mr. WEINBERG. And that is exactly what I am saying. But I think ERDA is a great thing. Let me make that very, very clear. But ERDA is not by itself going to solve the shortrun energy crisis. I think we have to do something in addition.

Senator RIBICOFF. All right. I am very interested in what that addition is.

Mr. AUER. Well, if I may, Mr. Chairman, pick up from there and address myself to that issue itself.

S. 2744 DOES NOT GO FAR ENOUGH

In the first place, I very much support portions and only portions of the Energy Reorganization Act of 1973, S. 2744. But now, to pick from where you and Dr. Weinberg left off, this is not an objection to ERDA that you are speaking of, that I speak of and he speaks of. It is an observation that ERDA stops short of achieving further goals.

If I may put it this way, as presently conceived ERDA would be a research and development agency, and as such its ultimate aim would be to bring new and improved technologies to the point where their commercial feasibility was demonstrated. And I underscore the word demonstration. Now, in the normal sequence of events, when this happens in an ordinary peacetime economy, whether this is done by Government funds or by private industry itself, the determination and the final analysis of whether this new technology or innovative technology is to be implemented and placed into wide commercial use is left to the marketplace to determine.

What I suggest at this time is that we are not operating under normal conditions, and that there is very little guarantee that we will return to normal conditions as we knew them for some time, as long as marginal oil production capacity is under the tight control of a foreign cartel. And I would argue there is a need for the Government to create an institutional framework which can take unconventional technologies all the way from the test tube stage to full commercial production.

Now, ERDA does part of that job. It carries out the demonstration phase. But what about putting it into production?

Up to a certain extent, as Dr. Weinberg mentioned, I do view the synthetic rubber program of World War II as a course of action which illustrated the position I am advocating.

Now, my full statement which with your permission I should like to present for the record——

Senator RIBICOFF. Gentlemen, your statements will go in the record as if read.

[The statements referred to follow:]

STATEMENT OF ALVIN M. WEINBERG, DIRECTOR, OAK RIDGE NATIONAL LABORATORY

I am grateful for the opportunity to speak in favor of the ERDA bill, S. 2744. Since previous witnesses have already spoken to many of the administrative details of the proposed Energy Research and Development Administration, I shall confine my remarks to two major issues:

1. What are the primary goals for an energy R&D strategy?
2. Is the proposed structure of ERDA adequate to achieve these goals?

ENERGY R. & D. GOALS AND STRATEGY

I am submitting for the record a paper entitled "A Strategy for Energy R&D" which I prepared with the help particularly of C. C. Burwell of the Oak Ridge National Laboratory. This is a very personal attempt to visualize the energy problem from the point of view of one who has spent most of his life thinking about nuclear energy. Here I shall summarize some of the important points covered in my paper.

(a) There is a consensus that in a general way "energy self-sufficiency" is a desirable goal. However, this is a goal that is difficult to make precise. In my paper I suggest energy self-sufficiency to mean keeping our oil and gas imports by 1985 to no more than 15 to 25% of our total oil and gas demand; and beyond 1985 to keep the absolute number of barrels of imported oil no higher than the level reached in 1985.

(b) Our basic strategy for achieving this goal is to shift from oil and gas (which we must import) to coal and uranium which we possess. In addition, we must try to increase domestic production of oil and gas.

(c) But this strategy alone will probably not achieve our aim of keeping imports below 15–25% by 1985; we shall have to impose strict measures of conservation, even if all of our technological ventures are fully successful. We must aim at reducing demand from an historic increase of more than 4%/yr to about 3%/yr in the next decade. This will reduce the projected U.S. demand from 125×10^{15} Btu to perhaps 100×10^{15} Btu by 1985. To devise conservation measures that at the same time cause minimal economic dislocation will require careful economic research and policy analysis.

(d) Beyond conservation, there are two major thrusts to our short-term R&D strategy—coal and nuclear. We estimate that by 1985 we may require as much as 1800 million tons of coal/yr (a fair portion of which will be hydrogenated) and 70,000 tons of uranium. These represent, respectively, three times and five times as much coal and uranium as we are now mining. Any R&D strategy must in the first instance do whatever is necessary to: (1) Guarantee the validity of our coal option. (2) Guarantee the validity of our nuclear option.

These three—conservation, coal option, nuclear option—are the primary elements of what I call the Short-Range Program.

(e) The other possibilities—breeder, solar, geothermal, fusion, and lesser sources of energy—are longer range possibilities and constitute what I call the Long-Range Program. These possibilities must be pursued, but it is clear that they can have very little impact in the next 7 to 10 years, though solar water- and space-heating and some geothermal may be of importance within this period.

CAN ERDA ACHIEVE THE ENDS OF THE SHORT-RANGE PROGRAM?

It seems to me that the two most fundamental questions concerning ERDA are:

(a) Can ERDA, which is in good part an enlargement of AEC, be counted on to give proper emphasis and force to the three short-range elements of the program—conservation, increased production of oil and gas, and coal—which are not nuclear?

(b) Can ERDA, which is a research agency separate from the commercial energy community, organize its research to be adequately responsive to real energy problems in a real world?

To both of these questions, my answer would be yes. As for ERDA giving adequate attention to coal, I see no problem here. After all, the Office of Coal Research and the Bureau of Mines energy centers and synthane plants will be part of ERDA: the expertise now within Government will be available in ERDA. But there is another point: coal research in this country has suffered from fragmentation and from lack of funds; it has never been pursued with the aggressiveness and coherence that characterize nuclear development. I should therefore think that the combination of experts from OCR and Bureau of Mines, and the aggressive coherent style of AEC research, should assure coal full and responsible attention.

ERDA's role in increasing domestic oil and gas production is rather less clear to me, especially since so much of this technology is in the hands of private industry. Fundamentally, I see no reason why with the authority given it in S. 2744 ERDA could not sponsor needed research that is not adequately performed within industry.

As for conservation, I would point out that several of the AEC laboratories already have considerable work going on in energy systems modeling and energy conservation. Some of this work is sponsored by AEC—for example, the studies on systems at Brookhaven; some of the work is sponsored by NSF—for example, the studies on energy conservation at Oak Ridge. Thus within the AEC structure there are substantial nuclei of people who are concerned with energy conservation. I see no reason why under the ERDA setup such studies cannot be strengthened and expanded, possibly including within ERDA an Institute of Energy Analysis that would help bring such studies of energy conservation and energy policy into sharp focus.

As for ERDA relating its research to real problems in the real world, I have no qualms on this score. After all, the entire civilian nuclear reactor program is a prime example of a government-sponsored research enterprise that gave birth to a major industry. Now that civilian reactors have become largely incorporated into industry, AEC no longer plays a central role; but there are innumerable continuing instances of fruitful exchange between industry and the Atomic Energy Commission. I would expect much of this experience to be carried over into the ERDA setup.

CAN ERDA CARRY OUT THE LONG-RANGE PROGRAM?

The Long-Range Program centers mainly on breeders, fusion, geothermal, solar, and other lesser modalities. These long-range energy systems largely work outside the marketplace. Their character resembles that of fission at its inception—basic uncertainties as to feasibility, both economic and technical. It would appear to me that the ERDA structure, with an Assistant Administrator having responsibility for these long-range modalities, would do full justice to their aggressive and timely investigation.

Finally, I ask: Will ERDA with its large nuclear background really be capable of transcending its nuclear heritage, and thus give to the other modalities adequate backing? I think the experience of AEC in changing priorities is good. I have in mind particularly the great surge of interest in fusion in the face of AEC's original commitment to fission. This enthusiasm was generated by creation within AEC of an office with sole responsibility for fusion. I believe that the required commitment and enthusiasm for the non-nuclear modalities, both long- and short-range, will develop within the Energy Research and Development Administration as organizations to pursue these methods of generating energy are created under the appropriate Assistant Administrators.

In summary, I would assert that ERDA under a strong, farsighted Administrator and with adequate backing by the Congress and the President, will prove to be an adequate instrument for achieving both our short-term and long-term goals in energy research and development.

STATEMENT OF DR. PETER L. AUER, PROFESSOR OF AEROSPACE ENGINEERING, CORNELL UNIVERSITY

Mr. Chairman and members of the committee, may I express my appreciation for being asked to appear in front of you to testify in connection with the proposed Energy Reorganization Act of 1973 (S. 2744). Prior to beginning my testimony I should like to insert for the record a brief resume of my professional background. Since the summer of 1966 I have been serving as Professor of Aerospace Engineering at Cornell University, where in addition I have filled the positions of director of the Laboratory of Plasma Studies and codirector of the interdisciplinary Energy Project. For two years before going to Cornell I was Deputy Director for Ballistic Missile Defense Research in the Office of the Secretary of Defense. Prior to that time I served in various research and managerial capacities with private industry, and during this period I had occasion to spend three years at what is now the Lawrence Livermore Laboratory and one year at the Argonne National Laboratory. At various times I have acted as a consultant to government agencies and private industry. Since the latter part of this summer I have been a consultant to the Chairman of the U.S. Atomic Energy Commission in connection with her December 1 report to the President on the $10 billion—five year energy research and development program. I am a Fellow of the American Physical Society and my major field of specialization is plasma physics.

I should like to turn now to the substance of my testimony.

DIMENSIONS OF THE ENERGY PROBLEM

For the past several years many observers of our energy sector, and I count myself among them, have been calling attention to the serious problems destined to face our nation as demand for energy began to outstrip our capacity for meeting it. Early signs began to appear some three to four years ago when certain parts of the country encountered temporary shortages of electricity which were blamed on unanticipated delays in the completion of nuclear generating plants. A very significant shortage began to develop in natural gas supplies at about the same time as our consumption rates exceeded replenishment rates from domestic sources by a factor of two. Electricity and natural gas have been the fastest growing forms of energy demanded by society. In the quarter century period from 1947 through 1971 installed electric generating capacity has increased seven fold and consumption of electricity has grown nearly as rapidly. During this interval natural gas consumption increased five fold. By comparison, gross energy inputs to the economy doubled approximately in this time interval.

If we average growth in gross energy consumption over the past quarter century, we find the annual rate of increase to be 3.2 percent. Over the past decade, however, it has been growing at the steeper rate of 4.3 percent annually on the average. The change between 1971 and 1972 reflected a 4.9 percent increase in gross energy consumption. It is clear that society has been evolving to a more energy intensive form. At the same time there appears to be a strong correlation between the amount of energy used per capita and our level of affluence as measured by the gross national product (GNP) per capita.

Petroleum, primarily crude oil, has been for some time our most popular form of raw fuel. Together with natural gas it accounts for approximately three-fourths of our total energy requirements. Until recently consumption of oil has increased at nearly the same rate as our total energy demand. As availability of natural gas became limited, as environmental considerations forced many coal fired steam plants to turn to low sulfur fuels and as the introduction of emission control devices on new cars led to an increased demand for gasoline—the burden on oil to meet energy requirements increased proportionately. The known reserves of oil are estimated to be 33 billion barrels in the contiguous U.S. In 1972 we consumed nearly 6 billion barrels of oil and natural gas liquids. Of this sum about 3.5 billion barrels came from domestic output, representing not quite 60 percent of our gross requirements, with the remainder made up by imports. The United States has relied on oil imports and to a more limited extent on natural gas imports for many years. Within the past few years, however, domestic oil production appeared to have leveled off along with natural gas. Increases in demand have been met almost entirely by corresponding increases in imports.

Our traditional sources for foreign oil have been in the Western Hemisphere, principal suppliers having been Canada and Venezuela. Production rates in these countries have also reached an apparent plateau. The United States now had to turn with increasing attention to Eastern Hemisphere sources, principally to the Persian Gulf states where some two-thirds of the world's oil reserves are known to exist, in order to meet our import requirements. At the same time the other industrialized nations of Western Europe along with Japan were placing increasing demands on these same suppliers. To whatever degree marginal production capacity could be increased readily, it appeared that this was under the control of a few oil exporting states.

These trends had been predicted and accepted by many within the past couple of years. It was also recognized that the exporting nations representing marginal capacity could band together to form a cartel which could control supply and dictate world oil prices. Some interesting public debate arose among oil experts whether such developments would ever take place. The events of the past two months have laid earlier speculations to rest. The cartel exists in full force; its power at the moment is being used for political purposes. World oil supplies and prices have undergone wild gyrations. What appeared six months ago to be a matter of serious concern to the United States has now reached the gravity of a crisis.

THE NEED FOR ACTION

Few individuals will question that there is an urgent need to formulate a firm and comprehensive national energy policy in the light of present events. I trust that many would also agree with me in concluding that presently existing institutional arrangements are not adequate to meet the challenges faced by our nation and that we must devise more suitable forms for future action.

The necessity for finding means to decrease our reliance on foreign energy supplies is quite evident. For the immediate future there is little choice but to

curtail energy consumption through the enactment and enforcement of appropriate policy. The Executive Branch and the Congress are already fully occupied in examining the alternative ways, by which this can be brought about. While today's considerations are an outgrowth of an emergency situation, there's every likelihood that damping the growth rates of energy demand will continue as a matter of national policy for some time to come. We stand on the brink of instilling a conservation ethic within our society. All of us, I'm certain, will be anxious to see how our economy and society adjusts now that the full measure of energy demand remains unsatisfied and as the price of available energy begins to climb.

Expansion of energy supply will undoubtedly take longer. There are, of course, the uncertainties of new developments on the international political scene. Embargos imposed over night can be lifted just as rapidly. Foreign oil may once more become as available as it appeared to be six months ago, even if at a higher price. Personally, I wouldn't want to bet on it happening very soon. Nor do I believe it would be prudent to allow our economy to become dependent on imports which are under the control of a foreign cartel.

Some immediate relief of shortages in natural gas and oil can be obtained if we alter existing regulations which prohibit the burning of high sulfur content fuels. This again is a policy issue requiring one to weigh the merits of relaxing environmental restrictions—if only on a temporary basis. Similarly, some additional electricity from nuclear energy could be obtained sooner if certain regulatory practices now in force were altered.

A number of econometric studies have indicated that dramatic increases (on the order of 50 percent) in natural gas and oil production from domestic sources would result from allowing the price of these commodities to rise above their presently controlled values. We are now addressing the issue of price elasticity in gas and oil supply—a subject in which I have no first hand knowledge. Nevertheless, I have the impression that exploring the issue from the point of government policy is not an easy matter. Nor can we expect to see positive effects in a very short time even if the right steps were taken. It takes time to develop new oil and gas fields and it takes time to build additional refinery capacity and distribution networks. There is also a very real question of just how rapidly the oil and gas industries can expand in view of potential limitations in skilled manpower, essential materials and available investment capital.

The response of industry towards expanding energy supplies whether of domestic or foreign origins will depend to a great extent on what policies the government adopts. Industry's allocation of its resources will in turn depend in large measure on how they read signals coming from Washington. Should they build tankers to carry liquid natural gas (LNG) from foreign shores, should they build supertankers to bring in foreign oil, will we construct deep water ports, where should new refineries be constructed, can we expect that the outer continental shelf (OCS) will be made available for leasing—these are but some of the questions whose answers depend on what policies the government adopts.

In view of the diversity and complexity of these issues it is essential that energy policy coordination be implemented with a firm hand at a single focal point within the government. In order to function effectively this office will require a depth of technical expertise and the full cooperation of all the government agencies with a role to play in the energy field.

As yet I have not really touched on what represents the largest potential domestic sources of fossil fuels, namely coal and oil shale along with oil contained in bituminous sands and viscous deposits. I raise this subject now in order to introduce a collateral matter to the point made above on centralizing energy policy.

The issue is as follows. A technology exists for extracting oil from shale. There is also a federal policy in effect which will begin offering federal land containing oil shale deposits for lease to private industry. Will industry respond? There's good reason to believe industry will not respond until the government policy is clarified even further. The capital investment required to secure added oil production in typical Mideast fields may range from $100 to $200 for each barrel of oil per day to be produced. In the North Sea or the OCS these costs may rise to $1,000 for each barrel per day of production. By comparison it is estimated that it will require on the order of $5,000 of capital investment for each barrel of oil per day to be produced from shale. In a free market for oil, shale would be in a very poor competitive position. But, there is no free market in oil, in fact it is highly artificial. It may cost no more than 10¢ to deliver a barrel of oil to a Mideast point of transshipment; by the time it reaches its destination its price will be above $5 or $6 per barrel in today's market. At these prices, were they to hold firm or increase, oil from shale could be produced competitively.

A somewhat similar situation exists with regard to producing synthetic pipeline gas from coal. A technology based on foreign developments exists. Its commercial demonstration is now underway in Scotland with the sponsorship of several U.S. companies. While the technology does not accommodate all varieties of coal to be found in the U.S., plenty of western coal is available which could be used with it. Once again, sizeable capital investment would have to be committed to the construction of such plants and the attendant coal mines. The resulting price of synthetic gas would be considerably higher than the present controlled cost of natural gas, but it might be competitive with imported LNG or gas piped over long distances from Alaska and Canada.

The above offers two examples of technologies which are close to commercial realization but for uncertainities in world fuel supplies and their price. Other examples will be furnished subsequently where technology is not far enough advanced for immediate commercial application but by accelerated development could be brought to that state within three to five years. The basic question is what should the government do to stimulate the commercial introduction of such nascent industries under the artificial non-free market conditions which seem to prevail.

I would suggest that the appropriate reaction on the part of the government to the emergency conditions existing today is to establish a synthetic fuels administration program along lines similar to the synthetic rubber program established during World War II. The function of such a program would be to implement technology ready for commercial application in contrast to research and development whose function is to demonstrate that a technology is commercially feasible.

Under normal conditions one usually relies on market forces to determine when and if a new technology should be introduced in the market place. A proper peacetime role for the government might be to stimulate the development of new technologies judged to be in the general interest of the public. It could, as it has in some past instances, enter directly into the research and development phase when occasion demands that it do so. After the technology has passed its early demonstration phase, the government could adopt policies which would induce industry to use its resources to apply it on a wide commercial basis. To a large extent this is the manner in which the present civilian nuclear energy industry evolved.

In my opinion present conditions call for abnormal responses and actions on the part of the government more in keeping with wartime rather than peacetime conditions. The Synthetic Fuels Administration Program I've suggested would come fully armed with the Defense Production Act and any other authority it may require to join with private enterprise in establishing new energy industries based on current or near term technologies. As long as conditions warrant it would be one of the principal recipients of the technological inventions from a federally sponsored research and development program.

A NEED FOR COORDINATED RESEARCH AND DEVELOPMENT

The present crisis atmosphere has brought energy problems into sharp focus. We have some very serious short term problems ahead of us and not too many options available for solving them in the near term. But, we should not lose sight of the fact that our economy and society are destined to face energy problems continuously on an indefinite time scale. Only through sustained research and development can we hope to bring into balance the demand for energy with its supply, subject to constraints imposed by society's will and political forces.

Until not very long ago the bulk of federal involvement in energy research and development was restricted to the nuclear field. The larger R&D efforts of the government were concerned not with purely civilian matters but rather with the procurement of military weapons systems and space systems. Now it is widely recognized that federal involvement in energy R&D is essential, and for the first time the government is about to embark in a serious way into an area which traditionally was the preserve of private enterprise. New rules will undoubtedly be introduced, the respective roles of the federal government and the private sector may need sharper definition and cooperative arrangements between the two will have to be devised to suit a given objective.

We can list opportunities for research and development aimed at meeting both short term goals and longer term aspirations by grouping them into the following categories:

Conservation

(1) Reduce end user consumption.
(2) Improve conversion and distribution system efficiencies.

Fossil fuel option

(1) Increase domestic oil and gas production.
(2) Increase coal's share of the total energy supply.

Nuclear option

(1) Assure the short term option based on converters.
(2) Assure the ultimate viability of the fission concept by development of a suitable breeder.
(3) Demonstrate the practical effectiveness of the fusion concept as a potential alternative.

Renewable resources

(1) Demonstrate practical exploitation of geothermal energy.
(2) Demonstrate practical applications of solar energy.

To this list we must add a general category of supporting research in science and engineering related to the needs of present and future energy technologies. This would include, among other things, gaining a far more comprehensive understanding on the environmental impact of energy production and utilization than we now possess. We would also add to this category subjects which relate to energy policy studies.

While it may be relatively straight forward to set down in broad terms the elements of a coherent energy research and development program, it's quite another matter to fill in the details and establish relative priorities. Some of the program elements included in my list are relatively new in terms of government sponsorship, some have been funded at subcritical levels while others have in the past received a lion's share of federal support. Responsibility for program execution is currently scattered through a multitude of government agencies: AEC, DOC, DOI, DOT, EPA, NASA and NSF all share some responsibility for conducting energy related research and development.

Recognizing the extent of fragmentation and the need for coordinated planning the President directed this summer that the Chairman of the AEC prepare an integrated five-year energy research and development program by December 1. The task was herculian particularly in view of time limitations. With due respect I should like to enter here my sincerest admiration for the skills and determination she brought to bear on this effort. As I became involved in the December 1 exercise, I was continually impressed by the difficulties of reconciling individual proponent agency positions with an overall grand strategy. As an ad hoc measure the Chairman's report accomplished all that could be expected. But, I wouldn't recommend that the government continue to carry out its responsibilities in energy research and development by perpetuating interagency committees.

It is imperative, in my opinion, that a single agency within the Executive Branch be assigned full responsibility for formulating and conducting the federal government's role in energy research and development. In so doing this agency would use the full resources of other government institutions as well as the resources of the private sector which lend themselves to fulfilling the agency's mission. There are already examples where the government has chosen to centralize its R&D activities or to set up central coordination, for example, the creation of NASA for the space program or the establishment of DDR&E in the Defense Department. The task facing the central energy R&D agency will in many ways be far more difficult than that faced by the above illustrations. Energy industries are well established in the private sector and represent a large share of our total economy. The federal agency's relationship with this sector of the economy is destined to be considerably different from the NASA or DOD experiences. Energy problems are destined to change and the federal agency must have sufficient flexibility to adapt and readjust priorities. By comparison NASA's original mission could be put in very succinct form—place a man on the moon.

ERDA AND NEC

The functions of the U.S. Atomic Energy Commission can be divided into at least four categories.

1. Conduct research and development on nuclear weapons and nuclear powered naval propulsion systems. These efforts are carried out almost entirely in a classified atmosphere.

2. Conduct research and development on civilian applications of nuclear energy. Work in this area is invariably unclassified.

3. Produce weapons grade nuclear material and nuclear material for civilian purposes. Much of this is done under classified wraps.

4. License and regulate the use of nuclear energy in the private sector.

The President has proposed that the last of these functions, the one concerned with licensing and regulation be transferred to a newly created Nuclear Energy Commission (NEC). I applaud this move with many others, I'm sure. For some time the AEC has been encumbered by a conflict of interest in that it was both the advocate and the regulator of nuclear energy. Public confidence in AEC pronouncements was often conditioned by the awareness that this conflict of interest existed. The creation of NEC should remove the stigma of advocacy and allow the new agency to devote its full attention to safeguarding the public's interests.

At the same time the President has proposed that a newly created Energy Research and Development Administration (ERDA) take over all remaining functions of the AEC. I find myself in disagreement with this proposal. I do not visualize ERDA as an agency consisting of the AEC with its regulatory functions removed and with certain elements of Interior (DOI) added to it. ERDA should be the central federal agency for energy research and development which I described in the previous section. Its mission should be as I discussed in the same place. There is no need to encumber it with military programs shrouded in secrecy, which in turn are dictated by national security. The military application activities of the AEC belong to the Defense Department (DOD) and not to ERDA.

For historical reasons, which no longer have any validity, the Congress decided to vest all responsibility over nuclear research and development activities within the AEC. As matters now stand the AEC performs a service function to the DOD in developing nuclear weapons and propulsion systems. I can see no logical reason why these functions could not be transferred in toto to DOD without any disruption or degradation of the enterprise which has been responsible for providing our nuclear armaments.

The AEC supports three major captive laboratories which are engaged in weapons work, at Livermore (LLL), Los Alamos (LASL) and SANDIA. Each of these is operated by either a university or private contractor. Their institutional integrity need not be affected in the least by the transfer of functions I have proposed. Both LASL and LLL have long traditions of working in classified as well as unclassified areas. I should believe that the laboratory management could readily adapt to a change where they would serve more than one customer. Their talents and capabilities would be at the disposal of both DOD and ERDA, and for that matter any other government agency soliciting their services. Many research and development organizations have functioned effectively in this mode and I am not proposing something terribly novel. Since Sandia is concerned almost exclusively with classified work, I would assume their services would gravitate towards the DOD.

The disadvantages of including military programs in ERDA should be quite apparent. The reason for creating ERDA is to mount a major effort in a purely civilian field. The present military oriented portion of the AEC budget is approximately $1.5 billion annually. The anticipated federal budget for energy R&D is of a comparable magnitude. The size of the military effort would be hardly a small perturbation on what is supposed to be ERDA's principal mission. Furthermore, the necessity for ERDA to operate partially under strict classified procedures would further complicate its relations with the private sector. In addition, one would hope that in the course of time ERDA would enter into substantial cooperative programs with other countries. Such relationships could be enhanced, I should think, if ERDA had no military entanglements.

I should like to see ERDA as a bold new agency conducting an aggressive research and development program which would bring to fruition new forms of energy and better ways of using energy as well as finding improvements to present methods. The question remains what will happen when one of its projects reaches the successful demonstration phase. Under normal circumstances this becomes a question of how to transfer technology to industry, and various schemes have been proposed while history also provides examples. Under present conditions I still feel that extraordinary measures should be taken in implementing the commercial application of new technologies. Whether this belongs to ERDA or whether it requires a separate entity as suggested by my proposed Synthetic Fuels Administration Program is not clear to me at this time. Let me close this section by remarking that at the same time that decision is being considered one should also consider where to place the AEC's nuclear materials production facilities.

ERDA ORGANIZATION

ERDA's mission should cover the entire spectrum of research and development on energy production, conversion, transmission and utilization. As such, the following programs in existence should be considered for inclusion in ERDA.

1. All civilian programs within the AEC.
2. All energy research and development programs within the DOI.
3. All pollution control technology programs within EPA.
4. All energy related programs within NSF/RANN.

I am less sanguine on what to do about R&D in the transportation sector. There is a division of responsibilities at present between DOT and EPA in this area. I favor getting EPA out of the automotive technology business for the same reason I favor divorcing the regulatory functions of the AEC from its advocacy functions. It is not clear to me, however, what should be the relative position of ERDA to DOT with respect to transportation technology.

Allow me to conclude by expressing my hope that the Congress will act with all due speed in creating effective institutions for meeting today's energy crisis while safeguarding that these institutions will be equally competent to handle the serious challenges we are bound to face in future years. I can't be certain that my remarks may have helped in some way your deliberations, but I am most grateful for the attention given to me.

Senator RIBICOFF. I will stay with you until we start a series of votes, which may be about 3 o'clock, unfortunately, and if we cannot finish I would hope that we would have the privilege of submitting a few questions to each of you gentlemen for answers.

Mr. AUER. If I could just close the train of thought that I had. In the full testimony which is submitted I referred to creating a synthetic fuels administration program, which could begin today. It would take an act of Congress.

Senator RIBICOFF. And could this be done within the framework of ERDA as another title?

Mr. AUER. You could add it to ERDA; yes, sir. Certainly.

I think it is up to Congress to decide whether they wish to separate that from ERDA or if they wish to include it with ERDA.

This program in principle could start constructing first generation commercial plants based on existing technology today. For example, oil from shale, or producing synthetic pipeline gas from coal.

Senator RIBICOFF. Well, do you look at this as another atomic energy operation run by the Government, or is this run by private industry, the synthetic fuels?

INPUT FROM PRIVATE INDUSTRY

Mr. AUER. I would expect—well, of course I would expect that private industry would be the major agent. Private industry would actually construct the plants and operate them, the plants, with the Government exercising oversight and providing whatever incentives may be required, and choose such instruments as the Defense Production Act, subsidies, guaranteed prices, et cetera, to achieve the goals of this procurement program.

Senator RIBICOFF. Have you a price tag on this?

WHEN CAPITAL INVESTMENT BECOMES PROFITABLE

Mr. AUER. A price tag. We have some very rough estimates of what it would cost to build any one of these commercial plants that I spoke of. For example, a plant that would produce 100,000 barrels of oil per day from shale would probably take a capital investment on the order of $500 million. And this illustrates a point, perhaps.

What we are talking about is making a capital investment on the order of $5,000 for each barrel per day of oil produced, as contrasted with making a capital investment on the order of $100 to $200 for

the same production capacity in a typical Mideast oil field, or possible $1,000 in such difficult places as the North Sea, or perhaps on our Continental Shelf.

Senator RIBICOFF. Well, you make a very important point. Mr. Aiken, who is now our Ambassador to Saudi Arabia, told me that it would take $18,000 per barrel per day for the investment to work out the deal between the United States and the Soviet Union to get natural gas from the Soviet Union delivered to the United States.

Mr. WEINBERG. That is for gas, not oil. Gas is different than oil.

Senator RIBICOFF. No, I think he was using per barrel of energy. In other words, you are talking about a barrel of energy too, are you not?

Mr. AUER. I am speaking of a barrel of oil, and I think in Mr. Aiken's testimony he was converting to a barrel of oil in energy terms.

Senator RIBICOFF. And he was making the point to me, his figures were something like yours, that he felt in our own country for a third of the amount we were talking about in the deal between the United States and the Soviet Union, we could do better in the United States. So your figures are something like Aiken's.

Mr. AUER. Well, I am not your best witness in comparing my figures with Mr. Aiken's, but what I was trying to point out, sir, is that it may take anywhere from 25 to 50 times as much capital investment to bring oil out from shale as it would to bring oil out of a typical Mideast field.

Senator RIBICOFF. And if the Mideast fields are not available——

Mr. AUER. Yes, and on the basis of this very theoretical discussion you would argue that shale is a very poor bet. But since the Mideast oil not only is not necessarily available, and since the price of the oil that we get from the Mideast fields does not reflect its true cost based on capital investment, but is an arbitrarily inflated cost controlled by the cartel, I am arguing that it makes sense for the Government to evolve a policy which would assure industry, give industry the assurance that it may commit its resources to something which appears in an artificial sense to be uncompetitive with sources that actually are not available.

THE FEASIBILITY OF ALTERNATE SOURCES OF SUPPLY

Senator RIBICOFF. In August I was in London and had a long talk with Mr. McFadden, who was a director of Shell Petroleum. And this was just about when Libya had nationalized, taking over the major oil interests of this cartel. I think at that time oil was going for about $4 or $5 a barrel, and he said to me that when oil reached $8 a barrel, which he estimated to be just about now, that you could afford any alternate source.

He said, they have revised holdings of tar centers in Canada, and at $8 a barrel they do not need any subsidy. At $8 a barrel, they could make money.

And I suppose—when I see these shorts, these commercials on television, Exxon showing some of their pilot plants out in Wyoming with oil shale—and I suppose that $8 a barrel, it would be feasible for Exxon now.

INVESTMENT-PROFIT LINK

Capital goes where they can make a profit, and if we are talking about $8 a barrel, which we are, then you could probably find the capital in this country and in the world, as a matter of fact, to develop it.

Mr. AUER. Yes. But sir, it takes guarantee and it takes long term assurance. I fully agree with you that to the best of my knowledge at $8 a barrel oil from shale is competitive. But we do not have any plants. It will take us perhaps 3 years to get them on line. It will take 5 years for them to start making an impact, and we must guarantee that in the course of that time and for the lifetime of those plants, somebody is going to continue to buy oil at the kind of prices that is required for fair return on capital investment.

Senator RIBICOFF. Well, let me ask you, with the world being as it is and the shortage of oil and raw materials, do you see the price of oil going down?

Mr. AUER. I certainly do not.

Senator RIBICOFF. So generally, whether it is Government subsidies or Government guarantees, you are in a situation where it would bring the large return on the dollar.

SYNTHETIC FUEL DEVELOPMENT ABROAD

Before I forget, Dr. Weinberg, or you, Dr. Auer, what nations are doing the best job in synthetic development of oil from either shale or coal?

Mr. AUER. Well, as far as the technology for converting coal to gas of synthetic pipeline quality, the demonstration project which is farthest along is now almost under completion in Scotland, but it is being carried out under the auspices of a consortium of U.S. companies, some 15 companies. I am not sure I could identify them.

Senator RIBICOFF. So in other words, we are far advanced with the knowledge?

Mr. AUER. That process is in the judgment of most experts ready for commercial introduction, yes, sir.

Now, as far as extracting oil from shale is concerned, most parts of the world which were not as fortunate as we, and prior to the time that cheap oil was discovered, did this. It is an old art. It has been known for perhaps close to 100 years. Scotland, to go back there again, discontinued it in relatively modern times.

So that is a technology which our own Department of the Interior, through laboratories at the Bureau of Mines, has monitored and continued developing. That again, is a technology which is ready to be implemented fully.

Senator RIBICOFF. What other countries besides Scotland are getting oil from shale?

Mr. WEINBERG. The Soviet Union. In Estonia, they actually burn the shale and make oil and gas from it.

Mr. AUER. Scotland has recently discontinued it because of the influx of oil from Africa and the Mideast. But Brazil still does it.

TRANSFER OF AEC MILITARY ACTIVITIES TO ERDA OBJECTED TO

May I make one point, which is now off this subject, before I lose your attention, sir, to the vote, and that is a point that I object to in ERDA, and where I disagree with ERDA, and this is with regard to the bill under consideration, and this has to do with the proposal that the military applications activities now contained in the Atomic Energy Commission, the AEC, be transferred in toto to ERDA.

I think this would be a grave mistake. It is my impression that ERDA is being considered in response to the administration's decision to provide massive funds on the order of $10 billion over 5 years for energy research and development. But these proposed funds are comparable in magnitude to the present military portion of the AEC budget, which is approximately $1.5 billion annually, and transferring the AEC military program to ERDA would distort the relative significance of the civilian program, and I think it would handicap the Agency, and I see no particularly good reason why ERDA should be distracted from its principal mission, which is energy research and development and which promises to be a heavy enough task by itself.

I would suggest that military application activities of the AEC are functions which simply support the Department of Defense, and properly belong there. They should be transferred in toto to the Department of Defense. I believe this can be accomplished without damaging, or in any way degrading the system which is now responsible for providing our nuclear armaments, and the arguments which I have heard to the contrary have not convinced me.

Senator RIBICOFF. Now, this is very intriguing. When ERDA was first presented to me to take a look at it, I went immediately to what you are talking about and I said, why does this belong here? And there was a shrugging of shoulders, and they said, you are going to rock too many boats to put it anyplace else.

Why would you be rocking boats to put it in the Defense Department?

What is the problem?

MILITARY BUDGET OF LOS ALAMOS

Mr. WEINBERG. Perhaps I should say what kind of boat you would be rocking. I think it is fair to say that the civilian energy business has gotten something of a free ride by virtue of the fact that the military laboratories such as Los Alamos have big military budgets, and this gives them a certain freedom to investigate byways that often have civilian applications.

Because Los Alamos does have a military budget, it is able to move aggressively on doing things that are very relevant in the power business. I would hate to see this capability reduced.

Senator RIBICOFF. Well, would the Defense Department be against it?

Mr. WEINBERG. Well, it is not all that clear to me, if the Defense Department moved in and Los Alamos had to get part of its money from Defense and part from ERDA, that they would have the same kind of freedom. And I guess I would be reluctant to see the Los Alamos boat rocked.

Senator RIBICOFF. Well, this is a problem. I mean, almost everyone acknowledges that it was an anachronism, but they did not quite

know how to handle it at this time. In other words, without being expert and knowledgeable in this field, immediately I went to that and I got a very, very uncertain negative response, a shrugging that there was nothing else you could do.

Mr. AUER. I think if you pressed the issue, Senator—with all due respect to people more expert than I—I think you will continue to get a shrugging of the shoulders. Because, in fact, there is no fundamental reason why a transfer cannot be accomplished without doing any of the rocking of the boat that Dr. Weinberg alluded to. Transferring the function from the AEC to the Department of Defense should in no way cause difficulties to the laboratory management at Los Alamos and Livermore, except perhaps for a little bit of getting used to a new way of operating.

We have many splendid, excellent research organizations and institutions in this country which work both for agencies of Government that have absolutely nothing to do with defense, and work for agencies of the Government that are heavily involved in defense, and I have every confidence in local laboratory management at Los Alamos and Livermore, that they could adapt to having two prime customers rather than one.

Senator RIBICOFF. Let me ask you—we talked about the intermediate in 1980, and we talked about 1985.

RECOMMENDATIONS FOR SHORT TERM

Do you have any recommendations for the short term?

Mr. AUER. Yes, sir. A strong policy on conservation.

Senator RIBICOFF. What would that entail in your opinion?

Mr. AUER. Finding the best and least damaging ways to bring about a curtailment on the use of energy, to squeeze the fat out of the system without, at the same time, causing major dislocations in the economy or forcing large-scale inconveniences to society.

Senator RIBICOFF. I suppose you are talking about gas, and we all use the word "bloat" instead of fat.

How much bloat is there that we could squeeze out without hurting the basic economy of our Nation in your opinion?

Mr. AUER. I think that if we do this on a gradual time scale of a few years, something like 10 percent, approaching numbers of the order of 10 percent of the total energy, that we use and consume can be squeezed out without major disruptions.

CHANGEOVER TO SMALL CARS

Mr. WEINBERG. I think the most important point is the transition from large cars to small cars.

Senator RIBICOFF. In other words, do you see the possibility or the requirement that no automobile be manufactured that did not give at least 25 miles per gallon of gas?

Mr. WEINBERG. This is a tough economic question. One can argue, and I think properly, that if the price of gas increases enough, then we will automatically become a small car society.

Senator RIBICOFF. No matter what happens.

ENERGY-ENVIRONMENT CONFLICT

Let me ask you again—I am fighting the clock, you know. I am just trying to get priority questions. One of the great controversies is obtaining adequate energy without hurting the environment. This is a basic conflict.

Do you gentlemen have any suggestions as to how we get energy and still maintain the quality of the environment?

Mr. WEINBERG. I am not an impartial observer in this matter, but I believe I am justified in the assertion that a properly operating nuclear powerplant is probably the least environmentally damaging of any energy source. One of the keys to preserving the environment is to push nuclear, and make sure that the nuclear option is available.

NUCLEAR ENERGY SAFETY FACTOR

Senator RIBICOFF. Well, again as a nonexpert, the papers are full of complaints that nuclear energy is very dangerous.

Mr. WEINBERG. I said a properly operating nuclear plant.

Senator RIBICOFF. I know you said that. Does that mean that there are some nuclear plants not being operated properly?

Mr. WEINBERG. No; I would not put it that way. I would rather say, in opting for nuclear, we are taking a very small, but not zero, risk, that you might have some environmental problem. The risk is sufficiently small, that I think the nuclear option is likely to have less environmental impact than any other available energy technology.

Senator RIBICOFF. Would you gentlemen, as long as I have you here, explain to me atomic fission, breeder reactions, and atomic fusion?

Will you gentlemen give me a first grade primer for the record?

Mr. AUER. Well, I would be glad to, because I am less of an expert on this than Dr. Weinberg. Perhaps I can communicate it more effectively, and if I make mistakes——

Senator RIBICOFF. And why the differentials between them and what the differentials are?

FISSION PRINCIPLE

Mr. AUER. The reactors, as I understand it, we are now using, operate on the so-called fission principle, which is the same principle as employed in the first so-called atomic bomb. It uses uranium as the principal fuel, but in the process it utilizes an extremely small fraction of the potential amount of energy that is stored in the fuel, because it makes use only of a single isotope which occurs in very low concentrations in nature. And so we are using only a very, very small fraction. And these reactors—we might call them burners—they burn uranium.

A breeder, in the process of burning, replenishes the fuel by a series of nuclear reactions. It takes the uranium content, which is plentiful in nature, but does not react in an ordinary burner to any great extent, and it converts it into a new material, plutonium, if we are talking about uranium and plutonium. It converts it to a new material in such fashion that in the process of destroying a fissionable nucleus, it makes more fissionable material. For every one it destroys, it makes more than what it did destroy.

Senator RIBICOFF. And this is what they call "dirty"?

Mr. AUER. This is a breeder, because in the process of destroying the fuel that it uses to make fission, it makes in addition, more than what it destroyed.

Senator RIBICOFF. So this is what involves a potential danger?

Mr. AUER. There is no danger here, no. This is the way that the breeder works—no, I am not alluding to any danger. I am describing a physical process. I think this is, in fact, how the full, or the equivalent to the full utilization of uranium that exists on the Earth, and thorium as well that exists on the Earth, could be stretched almost indefinitely. Instead of using only a very, very small fraction—less than 1 percent of the fraction of the energy that is stored in the uranium, we could use perhaps one-half or three-fourths of the total energy that is stored in the uranium through the breeding process.

FUSION PRINCIPLE

Now, fusion is an entirely different thing. Fusion works on the same principle that powers the Sun. It makes use of light elements. In the Sun it is principally hydrogen, but under terrestrial conditions we would use a heavy isotope of hydrogen which occurs naturally and still another isotope of hydrogen which does not occur naturally, but can be made by a nuclear reaction from lithium.

Senator RIBICOFF. Well, why do you read that nuclear fusion does not have harmful implications, whereas the other types of nuclear energy do?

Mr. AUER. Well, those are incorrect statements. They distort the picture. The fact of the matter is that both fission and fusion produce radioactivity. There are differences, though. In the fusion process, you produce no fission products as such, because the ash from a fusion reaction is helium, which is perfectly stable and benign.

But you produce radioactivity, because in the course of fusion neutrons are produced which react with materials which surround the fusion reactor, and they become radioactive. So there is some radioactivity present because of that.

And I also referred to the fact that we have to use an isotope of hydrogen which does not exist in nature. The reason it does not exist is because it is radioactive, with a relatively short half-life. This is tritium. Tritium is also a product of fission as well as fusion. In comparing fusion and fission reactors, a number of people have concluded that the inherent hazards of a fusion reactor are far less than that of a fission reactor.

Senator RIBICOFF. Well, let me ask you, are there not some scientific verities that scientists can agree upon?

The controversy that we have about the safety of nuclear energy and nuclear powerplants is very, very controversial. You have prestigious men in the scientific community taking opposite sides of that question.

Is this not something that can be determined scientifically?

Mr. AUER. I do not think it is a scientific question, sir. Besides, very often you will find on a scientific subject, scientists disagreeing among themselves. In other words, not everything can be wrapped up into a nice tight bundle and put aside, that is it forever. After all, we did find through the marvelous genius of Einstein that Newton

was not exactly correct when he explained to us why that apple fell down, as it supposedly did.

SAFETY OF NUCLEAR REACTORS

Controversies continue to exist in science. But on the issue of safety, nuclear safety, I think what we are talking about here are the emotional spectrums, the large separation in opinion due to an emotional response.

As Dr. Weinberg said, how do you treat a finite but extremely small probability of a hazard?

And there are many, many other examples in our industrialized civilization where we accept such risks without circumspectly inspecting them or putting them under a microscope. For some reason, the nuclear issue has been signaled out as the one to look at. But we take risks all the time, do we not, when we get into an airplane, or we get into an automobile?

Mr. WEINBERG. To put it more quantitatively there have been estimates that the probability of a really serious fault in a nuclear reactor creating truly serious damage—let us say several thousand people killed—this probability has been estimated to be perhaps, oh, several thousand, perhaps 10,000 times lower than the probability that an airplane landing at the Los Angeles Airport would crash into the Hollywood Race Track when the race track is filled.

Senator RIBICOFF. What has been the largest loss of life or damage due to some accident in a nuclear reactor?

Mr. WEINBERG. As far as an actual nuclear incident in a civilian power reactor, the answer is zero. There have been some incidents in noncommercial reactors—there was the army reactor, the SL–1, in which three people lost their lives. That was about 15 years ago.

Senator RIBICOFF. How many nuclear reactors do we have that are now generating electricity?

Mr. WEINBERG. There are about 40 in the United States.

Senator RIBICOFF. About 40.

Why does there seem to be such a multiplicity of breakdowns or shutdowns or stoppages of nuclear energy plants?

Mr. WEINBERG. In point of fact, one has to look at the matter rather carefully, and examine the overall load factor and the overall availability of these devices. Then the record is really quite creditable considering that reactors are large-scale new devices. If you take all the large nuclear reactors in the United States, their availability has been in excess of 60 percent, which is not bad, and is comfortably close to the availability of large-scale fossil fuel plants. Reactors are very big things. They are complex, and they are subject to breakdown.

Now, when a fossil fuel plant breaks down, well, it is a fossil fuel plant that breaks down. It is not a Federal case, and you do not hear much about it in the newspapers.

Senator RIBICOFF. Well, you will hear about it, like in Santa Barbara, if you have some trouble offshore. The whole country heard about it, and heard about it with great reverberations.

Mr. WEINBERG. Yes, I suppose that is true. But on the whole I think the country is much more sensitized, and possibly properly sensitized, to nuclear energy, because there is no question that nuclear energy, if not properly handled, represents a larger potential hazard than fossil energy.

But the point is, we do understand more about nuclear energy, and we understand how to handle it properly.

Senator RIBICOFF. What I am getting at I think is the same thing. As far as you are concerned, you feel no sense of panic. You feel no sense of panic pecause of our so-called energy crisis. We do have the capacity of handling the crisis—short range, medium range, and long range—if we as a Nation are willing to make the commitment and take the steps necessary to solve each in turn.

Mr. WEINBERG. I would only correct one statement Mr. Chairman; I do feel a certain sense of—not panic, but enormous urgency—because while we do have in principle this capacity, unless we move and move very urgently, the problem is it is not going to be resolved.

Senator RIBICOFF. All right.

THIS COUNTRY CAN SOLVE ITS ENERGY PROBLEMS

But in the event, we have a sense of national urgency and commitment, this country can really solve its energy problem, and in many ways bring a new era of economic progress, such as this country has never seen before; because no other nation has all the potentials within its borders compared to the United States.

Mr. WEINBERG. Except possibly the U.S.S.R.

Senator RIBICOFF. Except technologically, we are so far ahead of them, and with their problems, while they may have all the sources, they do not have the technological capacity to address themselves on a crash basis, as we could.

Mr. AUER. I agree very much with the spirit of your remarks, Senator, but may I add that I would like to see not only the sense of urgency directed at our own immediate and future problems, but somehow opened up, so that in fact the United States could become a supplier of energy to other nations.

Senator RIBICOFF. That is right.

And now, if we succeeded in achieving short-, medium-, and long-range utilization of our technology and our raw materials, we undoubtedly could generate enough energy for our own needs, but also supply the needs of other industrial sections of the world.

Mr. WEINBERG. I think that is true. I think that is particularly true with respect to enriched uranium; one of the real possibilities for export from the United States is to build enriching facilities, that means making U^{235} from raw uranium and shipping it overseas.

NATIONAL COMMITMENT

Senator RIBICOFF. Now, if this Nation really accepted the challenge and made a commitment, the events of the past few months could really be a blessing in disguise for the long-range future of this Nation.

Mr. WEINBERG. I personally happen to think so, because the events of the last months, causing dislocation and even heavy unemployment have galvanized us into action. It is on this account that I want to repeat, although I am entirely in favor of ERDA, and I do not even have the same concerns that Peter Auer has about the military aspects, I do not think that ERDA, by iteslf, is going to answer the problems of the next 5 years or the next 7 years.

Senator RIBICOFF. So, you agree with Dr. Auer, that the synthetic fuel agency, or whatever you call it, offers the best short-range approach?

Mr. WEINBERG. Probably. It has to be studied a little more.

Senator RIBICOFF. Have you discussed this with anyone in the position of policymaking authority?

Mr. AUER. Oh, yes.

Senator RIBICOFF. And what reaction do you get?

Mr. AUER. Mixed; some are interested, some are not. I think that you will get close to a consensus, perhaps, that says it should be studied carefully to see if this is a wise course of action.

Senator RIBICOFF. I will not ask you who takes a negative point of view, because that is a confidence you would not want to breach.

Who takes a positive point of view in the position of leadership? I would not require you to answer unless you wanted to.

REDUCTION OF ENERGY DEMAND

Mr. WEINBERG. Perhaps I might state what the counterargument is. The counterargument goes something like this; that if we are sufficiently wise in instituting conservation measures; then we shall be able to reduce demand sufficiently so that the reduction in demand by itself will get us off this hook.

Now, I, myself, tend to be somewhat skeptical of that, but I really cannot prove it.

INCREASING DEMAND FOR ENERGY

Senator RIBICOFF. Well, I feel that that is all right for today, or a year from today, when you consider the population growth, and international needs as well as projected national needs; then you can undertake conservation and still have a tremendous shortage.

My understanding is that not too stringent methods of conservation could probably save us about 3 million barrels a day, which is about equivalent to what we are getting from the Middle East. But looking for the long haul, you are still going to have to increase your supply.

Mr. AUER. I think the killing counterargument is the one which says, if conservation will get us out of it, of the immediate difficulties, or at least alleviate the immediate difficulties, and if conservation achieves a curtailment of energy consumption, a concept with which I fully support; and then they say since the price of energy commodities will increase relative to other commodities at a fairly sharp rate, econometric studies indicated that additional supplies will come into being from domestic sources of their own volition because of the natural response of the energy industries, and the Government need not do anything more, except to assure that those prices are allowed to rise.

Senator RIBICOFF. Do you believe that?

Mr. AUER. I am somewhat skeptical, and I am merely offering still another insurance policy, which I think we can afford. We can afford to do both.

POURING $50 BILLION INTO THE ECONOMY

Mr. WEINBERG. Instinctively, I rather like the idea of injecting an additional $30 billion or $50 billion into the economy over the next

5 years, for a purpose that could very likely have enormously positive payoffs.

Senator RIBICOFF. Let me ask you; let us take your figure of $50 billion.

Mr. WEINBERG. That is about what it cost us to put a man on the moon.

Senator RIBICOFF. It cost $50 billion to put a man on the moon. Out of that $50 billion, how much do you think would have to be attributed to the Government, and how much of that $50 billion amount would have to come from the private capital?

Mr. WEINBERG. I am afraid I do not have that number, Senator. Professor Auer may now have that.

Mr. AUER. I do not have the numbers, sir, but my hope is that very little of that money would have to come from the Government, from taxpayer money.

Senator RIBICOFF. In other words, there would have to be a commitment from the Government to set up the agency to give the encouragement.

A PRECEDENT FOR A GOVERNMENT GUARANTEED PRICE

Mr. WEINBERG. And guarantee the price.

Now, you see, guaranteeing the price, is an old idea in the energy business. As you will recall, the first demonstration of a nuclear powerplant, the Shippingport powerplant, generated electricity at over 50 mills per kilowatt-hour. But the Government subsidized the price, so that the Duquesne Electric Co. was able to sell the electricity for about 8 or 10 mills. The Government subsidized it to the extent of more than 40 mills per kilowatt-hour.

So there is a precedent for this sort of thing. And again if the Government guaranteed a price per barrel of oil from shale, then I should think that you would have lots of interest. You may be able to do this with very little Government money.

Senator RIBICOFF. Let me ask you: along the lines of your respective testimony and projections, has there been much written in this field?

Mr. WEINBERG. You mean with respect to the possibility of a huge Manhattan-type project?

Senator RIBICOFF. Yes.

Mr. WEINBERG. No, I think this is an idea that people are just barely playing around with.

Senator RIBICOFF. Nobody has tried to put it together and mark it up, or cost it out, or anything else?

Mr. WEINBERG. Not really, but I think there is enough interest in the thing, so that you will be hearing about it.

COST OF SYNTHETIC FUEL PROGRAM

Senator RIBICOFF. What do you think the National Science Foundation, if they were requested, could cost out the cost of the synthetic fuel program? Do you think they could do this?

Mr. WEINBERG. Probably. I think the Atomic Energy Commission would be a good place to do this. I think the Department of Interior might be able to help.

In fact, one possibility, and I have not thought of it very carefully, would be a special task force to look into the possibility.

Senator RIBICOFF. But let me ask you frankly, do you two gentlemen have the capacity to give us a summation or is there too much involved?

Mr. WEINBERG. I should say, Mr. Chairman, that I have been having a number of discussions with several people about, in fact, establishing that kind of capacity. In my written testimony, I speak of an Institute for Energy Analysis, that might be created with this capacity.

Senator RIBICOFF. Well, that is supposed to be one of the functions of the Federal Energy Administration under Mr. Simon. He is supposed to have a data analysis.

He is now working on the short-range problems. But evidently ERDA, if the Atomic Energy Commission should be the base, must have a sufficient number of scientists and economists and statisticians and computer experts to maybe work that out.

Mr. WEINBERG. I think so.

Senator RIBICOFF. Are you gentlemen advisers, or are you an employee of the Atomic Energy Commission?

AEC CONSULTANTS

Mr. WEINBERG. No. I am an employee of the Union Carbide Corporation which operates the Oak Ridge National Laboratory under contract from the Atomic Energy Commission, and I am a consultant to the Atomic Energy Commission for this report.

Mr. AUER. I am an employee of Cornell University, but for the past 3 months, I have been a consultant to the Chairman of the Atomic Energy Commission, only in connection with preparing her report.

Senator RIBICOFF. All right.

Now, is it too much for me to ask you two gentlemen—we will make the request of Commissioner Ray. Is it too much for me to ask you to inform the proper authorities at the Atomic Energy Commission of what I am driving at and what I would like to know?

I think it is a lot easier as experts and scientists to explain what this colloquy has been about, and what we are driving at than for me to try to put it down in writing.

Mr. WEINBERG. Earlier today I did happen to speak to one of the Commissioners about exactly this point. His response was he had suggested something like this 4 years ago. So it is not a new idea.

Senator RIBICOFF. No, I do not think it is a new idea, but there are many great ideas that are buried away, and unfortunately for the sake of the country, they have been forgotten, and then they get revived. I imagine it would cost a lot more money today than if they had started 4 years ago, and we would be 4 years ahead of the game.

Mr. WEINBERG. Except 4 years ago oil was $2 a barrel.

Senator RIBICOFF. That is right.

Well, I am going to ask the staff to make that request of the Atomic Energy Commission, so they will not think that this is something that you are foisting upon them. I am going to suggest that it is as developed in our colloquy. And would they discuss with you what this colloquy was; so we would at least save enough time, not to go through what did he say, what did I say, and what did you say. I think we understand one another. But you can put it in much better language and be much more meaningful than I can, because I do not have the capacity.

Mr. WEINBERG. We will be glad to do that.

Senator RIBICOFF. Well, I do appreciate you gentlemen coming here today, and the seats are empty and the benches empty. Unfortunately, this is what happens in the afternoon—once the newspapermen leave, the Senators leave too.

But it has been very valuable because I think you have really opened up an avenue that so far no one has discussed. And I think to me, it is very important, too, and my gratitude to both of you.

Mr. Wager will get information to the Atomic Energy Commission about what we have done. And I think it is very important as we go along with ERDA to start putting our sites here.

[See appendix, p. 616.]

Mr. WEINBERG. Thank you very much, Mr. Chairman.

Mr. AUER. Thank you very much.

Senator RIBICOFF. Would there be anything else either one of you gentlemen would like to add?

Mr. AUER. No, I do not think so. We never did get to the Nuclear Energy Commission. For the record, I am 100 percent in favor of it.

Senator RIBICOFF. You are in favor of it?

Mr. AUER. One hundred percent in favor of setting up the Nuclear Energy Commission. The splitup of the AEC in this context is marvelous. I think it will help a great deal.

Senator RIBICOFF. Well, thank you very much.

I want to have the opportunity of saying goodby to you.

[Whereupon, at 3:25 p.m., the subcommittee recessed, subject to the call of the Chair.]

TO ESTABLISH AN ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION AND A NUCLEAR ENERGY COMMISSION

WEDNESDAY, DECEMBER 5, 1973

U.S. SENATE,
SUBCOMMITTEE ON REORGANIZATION, RESEARCH,
AND INTERNATIONAL ORGANIZATION,
COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 10:10 a.m., in room 1318, Dirksen Senate Office Building, Senator Abraham Ribicoff (chairman of the subcommittee) presiding.

Present: Senators Ribicoff, Chiles, Nunn, Percy, and Roth.

Also present: Paul Hoff, legislative counsel, and Susan Geoghegan, chief clerk.

Senator RIBICOFF. The committee will be in order.

Our first witness is supposed to be Senator Cook, who is not here yet.

Would it be an imposition on you, Mr. Freeman, if I asked you to start and would you mind being interrupted when Senator Cook comes? This way, we can save time?

Mr. FREEMAN. Mr. Chairman, I would be delighted.

Senator RIBICOFF. Thank you very much.

TESTIMONY OF S. DAVID FREEMAN, FORD FOUNDATION ENERGY POLICY PROJECT, ACCOMPANIED BY J. FREDRICK WEINHOLD

Mr. FREEMAN. Mr. Chairman, I have with me this morning Mr. J. Fredrick Weinhold, who was with me in the White House Office of Science and Technology for many years and is now associated with me in the Ford Foundation Energy Policy Project. I guess between the two of us, we have spent as many years as anyone trying to make sense out of the scattered array of agencies in energy research and development.

Mr. Chairman, we have a prepared statement that we would like to submit to you.

Senator RIBICOFF. Without objection, the entire statement will go in the record as read.

[The prepared statement of Mr. Freeman follows:]

STATEMENT OF S. DAVID FREEMAN, FORD FOUNDATION ENERGY POLICY PROJECT

Mr. Chairman and members of the committee: I am delighted to be here to discuss legislation to consolidate and strengthen the Federal energy research and development activities. This is a subject with which I have been heavily involved with for many years, four of them in the White House Office of Science and Technology where we struggled with the programs and agencies on a piece meal basis.

I am accompanied by J. Fredrick Weinhold, who was my associate when we were in OST and who is now working with me on energy R&D at the Ford Foundation Energy Policy Project. Our testimony is personal and based on our intimate experience with this issue in government and subsequently. The Project reports will be completed in the coming months, but our testimony today represents our personal views.

The current energy crisis and all of the attendant problems points up the importance of energy in both the short and long run. These problems are not going away in a few months or years but will probably be with us for the rest of our lives. It will take a long term effort to overcome them. The establishment of an energy research and development administration is an important step forward in developing successful energy policies for the country. The present array of separate agencies just won't do. Based on our experience in the Executive Branch, the agencies working on non-nuclear R&D lack both the scope of program and the critical mass of in-house competence to get the job done. The existing agencies in energy R&D are singleminded—by design. No one is responsible for putting together an urgent across-the-board effort. There needs to be an agency with a single administrator to bring together the kinds of projects needed for the future and I believe S. 2744 provides a good framework for such an agency.

In addition, the other reform that the bill provides—the separation of regulatory and operational functions—is long overdue. The public must have greater confidence in the licensing of nuclear facilities. We need to be sure the licensing agency has no responsibility for promoting nuclear energy. Under such a new commission, I believe that people generally will have greater confidence in the licensing work. This alone justifies the reform.

As I stated the bill provides the essentials needed to establish a comprehensive energy R&D agency. Nevertheless it is not a cure-all. I am concerned that an agency which is confined to research and development, divorced from the energy policy-making and from the real operational problems, could wither and could get off the track over the years. Energy is such an important issue that we should be working toward the creation of a Department of Energy. Perhaps this Energy Research and Development Administration could be the nucleus of it, but in passing this legislation and establishing ERDA to pull the R&D together under a single leader we should recognize that we are just beginning the reorganization needed in this area.

The most serious concern I have about ERDA is ensuring that it is not just the Atomic Energy Commission by another name. If you combine a mountain such as the Atomic Energy Commission and a few molehills, such as the research programs in the other areas you may still end up with the same "mountain." We must be sure that nuclear energy does not dominate the new agency. I know this is not the intention of the Committee, nor of the statute, but many people are concerned that this might happen. The organization of assistant administrators provided in the bill is intended to overcome this concern and should go a long way to allaying these fears, but additional steps must be taken.

The problem of achieving balance and a new thrust cannot be solved by the table of organization. The most important decision with respect to this new agency is the appointment of the Administrator to head it. In order for the public to accept the fact that this is really a new agency, someone new and independent should lead it. Policy-making officials in government who are presently promoting atomic energy or coal should not be appointed to head this agency. It seems to me quite important that we bring fresh new talent with a "can do" point of view to give the general public confidence that we have created a new entity that will get this job done. Individuals who have been involved in preparing their own R. & D. budget, be it for coal research, atomic energy or any of the programs that we now have, will either have to lean over backwards to prove that they are being fair or risk criticism of being proved unfair.

I should now like to offer a number of suggestions to strengthen the new agency. In order to assure a new balanced program the new administrator should be directed by the statute to provide a new energy R. & D. plan for the agency. He should not be tied to the programs put together by the Atomic Energy Commission or the Office of Coal Research. At the end of the first year and each subsequent year he should be required to present to the Congress and to the American people a ten-year plan to accomplish the job we want done, a plan that has been circulated for review to the Environmental Protection Agency and the Anti-trust Division of Justice.

A requirement for such a 10 year look ahead would serve two purposes. It would give the new administrator a mandate to make a fresh start, to review

everything that is going on, and to develop new programs. It would also give the Congress on opportunity to focus on the crucial first budget. He should develop a plan similar to the one the Atomic Energy Commission issued in 1962 which laid out a long term program for the development of nuclear power which we are still following. The following language would translate this idea into a Section of the Act.

PROPOSED SECTION 103(8)

Each year at the time the administration's budget is submitted to the Congress for authorization and appropriation, the administrator shall submit to the Congress a report which:

(a) Assesses the state of energy technology in the United States and abroad;

(b) Presents a detailed federal energy research and development plan for the next ten years, including specific programs, milestones, and deadlines for their completion;

(c) Incorporates the comments of other responsible federal agencies on environmental and anti-trust implications of the plan.

In preparing this plan it is important that the administrator take account of public concerns, especially for the environment and the economic costs of energy. There needs to be positive mechanisms to ensure that these are the integral part of the ERDA planning process. The statute should require an advisory committee truly representative of a broad segment of consumer and environmental concerns as well as the traditional energy industry interests. Public hearings held on the annual report by the administrator and by the Congressional authorization committees would also provide a route for public input.

Over the longer run a more comprehensive means for assessing the many intentional and unintentional impacts of new technologies is needed. One way of providing this broad objective review is through a special office within ERDA charged with assessing the new technologies being developed by government and industrial programs. A statutory requirement that the budget for this office be 1 or 2 percent of the total ERDA budget would assure that the task is taken seriously.

One of the prime reasons for creating the new agency is to provide a new thrust for non-nuclear R&D which has been neglected in the past. Those who have criticized the Atomic Energy Commission's program mainly because the Interior Department and other agencies have not been able to mount strong R&D programs have really been unfair. We should not be dividing up a fixed pot and holding back the only programs that are moving ahead. We need new programs for coal, solar energy, geothermal and energy conservation technology. It is important that this bill reflect the sense of the Congress, that we want to continue to work as hard as we can on the things that are underway, but we want to launch new programs in the areas that have been neglected. To carry out this objective a section could be added to the bill directing the administrator, because of the past neglect on non-nuclear research and development, to undertake new programs for all such sources that hold promise of large supplies of economic energy on as large and rapid a scale as the state of the art permits.

It seems to me language to that effect in the statute would give the administrator a sense of direction for new programs and reflect a genuine concern.

There are two special problems associated with using AEC as the nucleus of the new agency. As it stands a major fraction of ERDA's efforts will be addressed to military R&D and the production of weapons. A number of persons including myself have expressed concern with this diversion of interests and efforts within an administration charged with finding solutions to civilian energy problems. The new administrator, the person in charge of energy R&D, must also learn about and be responsible for a military program which exceeds $1 billion per year. I understand the arguments for keeping all the nuclear work together and the problems of separation. But they do not outweigh the cost of an ineffectual civilian energy R&D agency. For practical reasons I would not delay establishment of ERDA because of this concern but I urge that the legislation require the new administrator of ERDA to furnish a report to the Congress on the combined functions with his recommendations based on his first year or two year's experience in running this agency. If the military side proves to be a diversion or if the administrator has more than he can handle, then recommendations for separating the military work would be in order. The first administrator should be required to make his recommendations on the basis of his experience.

Another item deals with the relationship between ERDA and the Nuclear Energy Commission. Questions have been raised about the authority of this new

regulatory agency over the facilities operated by ERDA. Section 202 of the bill covers this matter but does not go far enough in my view with respect to ERDA facilities which do not produce commercial power. It would be useful if the Nuclear Energy Commission were required to provide an advisory opinion such as the Atomic Energy Commission now provides for military reactors for all of its in-house facilities. Section 202 covers only new power reactors and waste repositories but it would be useful if the nuclear energy commission were to review the facilities owned and operated by ERDA at least on an advisory basis. This advice should be made public to give the public confidence in the process.

I would now like to move to the mechanisms the administrator can use to conduct his business once he decides which technologies to pursue. The bill provides extensive flexibility in arranging with industry, government laboratories and others to do R & D. In those cases where technology is close at hand it may make sense for the government to buy the results rather than to finance the construction of the technology. The administrator should have the authority to pull the technology out of the marketplace rather than to push it into the market.

The situation perhaps could be illustrated with the shale oil. If, as has been suggested, the technology is there, it is possible that the Federal government could use its purchasing power for oil to solicit bids for shale oil. It could agree to buy shale oil from the lowest bidder. The bid would include an environmental protection plan and be subject to the approval by EPA.

The procurement concept could also be the valuable mechanism for stimulating R & D on utilization technology. The administrator could work with General Services Administration, Department of Defense and other agencies which buy a lot of houses, cars and similar energy intensive systems to make some of these routine procurements part of an overall strategy to implement technology. It is my understanding that these mechanisms are within the scope of the draft legislation, but it is not obvious so I think it useful to emphasize these mechanisms.

There is a major advantage of using competitive bidding to pull developed technologies over the top by guaranteeing a market. It could produce faster results and it would release government funds to move ahead in the brand new areas such as solar energy which really need a big push over a number of years. Otherwise nuclear power and synthetic oil could absorb most of the federal dollars.

Along the same line, I think Section 103(6) should be expanded to provide the authority to enter into joint ventures with other governments when it is appropriate. It is conceivable that the Japanese or other governments might want to contribute financially to some of the R & D projects that we are proposing. I suggest that language could be added to Section 103(6) that would authorize such cooperation.

Another point that I would like to suggest involves the statutory assistant administrators in the organization. While the organization outlined in the bill identifies the various components of the agency and gives them sort of life of their own, it lumps conservation in the same boat with environment and safety.

For too long we have thought of research and development only in terms of the supply of energy. Research and development for more efficient utliization of energy should be an important enough activity to warrant a separate assistant administrator. Energy utilization is a very important aspect of the problem and deserves a separate box of its own.

A suggestion dealing with inventions grows out of our experience in government. When we were in the Office of Science and Technology we used to average one or two letters a week from potential inventors, small people who thought they had an idea but didn't have the money or know-how to develop them. The language in the statute would probably permit it, but I think a small office of inventions should be established which would, with the help of the ERDA laboratories, look at these ideas in sufficient detail to see if they have any merit. The office could provide assistance to the individuals and small businessmen who have good ideas. This could be a small but important part of an energy research and development agency—among all of the crackpots who write in there may be a Tom Edison or two.

The question of inventions and patents raises another problem with the bill. As it stands Section 103 distinguishes between nuclear and non-nuclear projects with respect to patent and contracting policies. There are valid reasons for doing this now. Lots of difficult patent policies and technical questions are handled differently in the Atomic Energy Act and in other government agencies. I know the difficulty in changing these provisions but I think that the administrator ought to be required within a year or so to propose a uniform system of patent policies and contracting authority so that projects are not whipsawed back and forth between nuclear and non-nuclear contracting authorities.

My comments have been wide ranging and probably too long, I urge passage of legislation to consolidate energy R&D. The bill before you provides a good framework for actions in a sadly neglected area. My suggestions will hopefully strengthen the new organization so that it achieves the promise we all hold for it.

Mr. FREEMAN. If I may proceed by just quickly identifying the major points, I shall do so.

First of all, we believe that the legislation before us to establish an Energy Research and Development Agency provides an excellent framework for a long overdue reform. As I said, we know from personal and painful experience how nearly impossible it is to launch the kind of program the country needs with the present scattered array of agencies in the energy R. & D. field. We also believe the reform of separating the nuclear licensing function, making it a separate, independent entity, is also long overdue. The basic legislation will accomplish two very much needed objectives.

The thrust of our testimony is to suggest amendments to strengthen the bill that is before you. But first of all, I would like to comment on what I think is more important than anything that can be put in the statute. That is the person that would lead this new agency.

Senator RIBICOFF. Senator Cook, could Mr. Freeman finish his comments, then I will suspend the questioning and you will then testify?

Senator COOK. Senator, I am the one who is late. I will wait.

Senator RIBICOFF. All right.

Go ahead, Mr. Freeman.

STRONG LEADERSHIP NEEDED

Mr. FREEMAN. Without belaboring the point, if we are to create a new agency to give us a new thrust in energy R. & D., it seems important that the legislative history show that we need new leadership that has not been involved in promoting atomic energy or any other sources, that will assure the country that we have a balanced program that will give every form of energy a new thrust. We need to move ahead developing the coal resources, solar energy, geothermal, and energy conservation technology.

So my first point is to emphasize that this agency cannot just be the Atomic Energy Commission by another name. It has to be a new agency in reality and the way to make it so is to bring fresh, strong leadership with a "can do" approach.

It seems to me that the bill should be amended to provide that the new Administrator shall present the Congress with a 10-year plan, a balanced plan of his own. He should not have to inherit the piecemeal R. & D. programs that have been developed and are still being developed by the Atomic Energy Commission and other existing agencies. The Congress should have, when it reviews the first year budget, a 10-year plan developed by the new Administrator. I think this should be a provision in the statute and my statement suggests language that might make that effective.

We believe that an Office of Technology Assessment should be a part of this agency and 1 or 2 percent of the budget should be earmarked for a special office to look at the impacts on society, on the environment, and on our way of life of the research and development before it is undertaken. We should no longer just plunge ahead with 10 or 15 years of a research and development effort and then begin to become aware of the side effects. I think it is important if this

activity is to be something more than just a sideshow, that the statute earmark a small but significant percentage of the budget for that activity.

ENERGY CONSERVATION

The subject of energy conservation, which belatedly is beginning to get some attention in this country, deserves more than just an association with the current crisis. Research and development can make major contributions to learning how to build houses, cars, and perfecting industrial processes that are more efficient. For too long, we have thought of reaserch and development only in terms of the supply of energy. I should hope that this agency would include an Assistant Administrator solely responsible for energy utilization and conservation. The present organization lumps that in with environment and safety. I think it is as important as coal research or nuclear research or any of the supply options and should be given that kind of prominence.

It seems to me that the statute should have an express mandate that we have to catch up on every source of energy, perhaps except for nuclear, which has had a strong program. The statute should give the new Administrator a mandate to provide as strong a program as the state of the art would support for solar energy, geothermal, coal, and every other source that has been so shamefully neglected over the last decade.

WEAPONS PROGRAM

On the issue of the weapons program, which would still be a part of this agency, we do not have a clear enough signal as to whether separation can be done efficiently or not. The statute, or at least the committee report, should require the new Administrator, after a year of experience, to report to the Congress on whether he thinks he can handle the weapons program and energy R. & D., whether it is efficient to keep them together or if not, make recommendations for transferring the military work to the Defense Department or elsewhere. It seems to me that there should be that sort of a check. He should use that first year to find out and then report to the Congress either that it is okay or that it should be separated.

INDUSTRY INVOLVEMENT

I believe the statute covers this point but I think it is important that the legislative history reflect that all new technology does not have to be paid for and pushed through the whole R. & D. process by the Federal Government. It is quite possible that some of the technology is close enough to commercial feasibility that if the Federal Government used its purchasing power, say its purchasing power to buy oil, and asked for bids from industry, perhaps we could get the technology pulled out of the marketplace faster and with less cost to the Federal Government than having a Federal R. & D. program in effect build plants. If industry is prepared, as I think they probably are, with oil shale, if we can eliminate the environmental bottlenecks, let us test the marketplace. Let's have a variety of programs and have more money left over for the projects that need Federal demonstration plants, because even if we develop a trust fund, we do not have an unlimited amount of money.

I do not believe the statute expressly calls for the possibility of joint ventures with other nations. I know the Japanese and others are planning a research and development program similar to our own and we ought at least to authorize the Administrator to enter into joint ventures with other nations where we can move faster and save money.

OFFICE OF INVENTIONS

Our last point is that I think that a small office of inventions should be in this agency. When we were in government, we used to get one or two letters a week from people, small people who just did not have the money to pursue their inventions. There is no place that many of them can go. This new agency with the Federal laboratories ought to have an office that will take a hard look at these letters and perhaps provide financial assistance if they merit it. Among all the crackpots, there might be a Thomas Edison or two. We should not just answer them with routine form letters saying that we have no capability.

Mr. Chairman, I believe those are the major points, in summary, that we make in our statement. Mr. Weinhold perhaps might have one point that needs to be added. I think we have covered most of them.

Mr. WEINHOLD. Yes, I just have one small point concerning the contracting authority and the organization. The bill provides a split in the ways of doing business between the AEC way and the non-nuclear way. To clear things up within ERDA, I think it would be useful if the Administrator could be charged with the task of developing a unified set of rules and patent authority which would not deal separately with nuclear and nonnuclear technologies.

Mr. FREEMAN. There is a fairly significant point along those lines. The Atomic Energy Act requires the AEC to keep the Congress fully and currently informed. It would be quite an anomaly if the Administrator, found himself responsible to keep the Congress fully and currently informed about nuclear research but not about the rest of the agency. It seems to me that anomaly should be corrected in the statute before it is passed.

Senator RIBICOFF. Thank you very much. Please stand by and we will get back to you, because what you have said is very provocative and there will be some questions.

Senator Cook, through the courtesy of these gentlemen, before you came, I asked them to testify, but to expect your arrival, and they agreed.

TESTIMONY OF HON. MARLOW W. COOK, U.S. SENATOR FROM THE STATE OF KENTUCKY

Senator COOK. Thank you very much, Mr. Chairman. I know these gentlemen and I respect them and their ideas.

Mr. Chairman, recently in an editorial, a well-known commentator stated that although it sounded perverse, he found himself half hoping that the Arabs would cut off, not 5 percent, but all oil to the United States. He reasoned that when it had to, the United States is capable of miracles, and while the cutoff now would merely provide us with a miserable winter, that the crisis would provide us with a necessary incentive which seems to be lacking by the people and their leaders to provide and implement the necessary programs so that this Nation would no longer be dependent on a foreign power for its energy

fuels. He was 50 percent right in that the Arabs have embargoed oil shipments to the United States. I think he may make the other 50 percent as we will solve this problem.

While I am much concerned over the hardship that some of the people of this Nation will face as a result of our situation today, I am nevertheless in sympathy with this comment, as I believe it has taken this crisis to shock the people, the Congress, and the President into taking action which is long overdue.

I am also in complete agreement with the President's recent comments:

> Whenever the American people are faced with a clear goal and they are challenged to meet it we can do extraordinary things.

Mr. Chairman, the challenge is very clear. We must find ways to produce and to use the abundant domestic natural resources with which nature has provided us so that we are no longer dependent on foreign powers for our energy fuels. We must accept these natural resources in the form in which they exist—not in the form in which we wish they existed. It is our problem to effect the desired conversion from so-called dirty fuel to clean fuel and to harness the many energy forces of nature. In this way we can meet our energy requirements. However, I hasten to add that in so doing, we must not sacrifice our goals of establishing and maintaining a healthful environment for all the people of this Nation. This is not an impossible task, and we are taking important, if belated and minimal steps to see that this is accomplished.

S. 2167

Mr. Chairman, to me such a goal can be achieved only through a dynamic research and development program. To this end, on July 13 of this year, for myself, Mr. Robert C. Byrd, and Mr. Baker, I introduced S. 2167, which would establish such a program, but more importantly it would provide adequate funding for this program by the establishment of an energy research and development trust fund. I am convinced that if we permit the research and development program to be dependent on annual appropriations, we must certainly risk attainment of our goal.

To me the situation is comparable to that which we faced in 1956 when the decision was made to undertake the construction of more than 40,000 miles of interstate highways. We recognized then that in order to achieve our goal we must have assured funding over the continuing period. We realized that we must remove the uncertainties inherent in dependence on annual appropriations. The decision was made by the 84th Congress and President Eisenhower to establish a highway trust fund for this purpose. Public Law 627 came into being. We now enjoy a highway network which I question would exist had we not created this fund. As we seek the best solution to funding required research and development energy programs, I think we would do well to consider the example.

S. 2694

On November 13, following the announcement by the President that he was recommending to the Congress the establishment of an independent agency, the Energy Research and Development Administration, to manage our energy research and development efforts, I introduced for myself, Mr. Baker and Mr. Bartlett, S. 2694, a bill

to establish the Energy Research, Development, and Demonstration Administration.

This proposal differs from the President's proposal, which was subsequently introduced by you, sir, and is the bill which we are considering here today, S. 2744, in that it provided specifically, not only for research and development, but also for the very important demonstration phase. From my own personal experience, I have found that when the research and development phase has been reached there has not been adequate provision for the demonstration phase to prove or disapprove, with a larger model, the validity of the research and development which has been completed.

As I study S. 2744, and its companion bill in the House, H.R. 11510, I note that while demonstration is not included in the title of the bill, it is provided for adequately within the bill itself. I also understand that it will be included with the House report. I therefore take no real issue with this particular point, only to say that demonstrations are vital to the success of energy development programs, and without adequate provision for this phase, the program itesif is incomplete.

There is also a difference in my bill concerning the actual organization and functioning of the Administration itself. This difference stems basically from your determination that it is more desirable for the ERDA to have an advisory board rather than a board of governors as provided in S. 2694. Here again, I take no real issue and I believe this is a detail which can be worked out to the agreement of all concerned.

NUCLEAR WEAPONS RESEARCH

There is also the consideration of the exact placement of nuclear weapons research. In my bill I have not included this type of research. However, I can see a very good reason for doing so if it is the desire to remove from the Atomic Energy Commission all research and development activity, and leave only those functions concerning licensing and related regulatory measures.

ENERGY TRUST FUND

There is, however, one basic and very important, and to me a vital difference in the bills we have been discussing. As I stated earlier, I hold that we need the energy trust fund. Without such fund our energy research would be built on a very chancy proposition. It would be subject to the whims and the desires of each successive Congress, and as such it would be hampered severely in its efforts to provide us with the answers to our problems.

I think we all accept the proposition that we need a dynamic research and development program or we would not be here discussing it today. As anyone who has been involved in major research and development programs will tell you, success is dependent on assured and continuous funding. Therefore, I say to my colleagues, what better way to provide this funding than the creation of a Federal Energy Research and Development Trust Fund? This fund could act as a repository for funds of a prescribed amount, and expenditure from the fund could be made to meet requirements as they occur over a continuous time period. I suggest a sum of $2 billion would be paid into the fund annually. I would not restrict or require that a specific amount be expended over a particular fiscal year to support a particular program. Such determination would be made by the Adminis-

trator to permit him to expend funds to meet requirements. It is vital to our purpose that we are prepared to support a scientific or technological breakthrough as it occurs and without reference to specific limitation imposed by a system of corporations.

In suggesting $2 billion as an annual sum I realize that this amount is a quantum jump in R. & D. expenditure. For the period fiscal years 1970–74 only $2,753 billion was funded. These figures were included in the President's first energy message, and I ask unanimous consent that a copy be printed in the record.

Senator Ribicoff. Without objection, so ordered.

[The above-referred-to document follows:]

ENCLOSURE 1

FEDERAL ENERGY R. & D. FUNDING

	Agency	Fiscal year 1970	1971	1972	1973	1974
Coal: Resources development		30.4	49.0	73.5	94.5	119.9
Production and utilization R. & D. including gasification, liquefaction, and MHD.	DOI, OCR	13.5	18.8	30.3	43.5	52.5
	DOI, BOM	13.2	15.4	14.7	19.8	18.1
Mining health and safety research	DOI, BOM	3.7	14.8	28.5	31.2	28.3
Interior central fund (part)	DOI					21.0
Petroleum and natural gas		8.8	11.5	12.9	12.8	9.1
Petroleum extraction technology	DOI, BOM	2.7	2.7	3.2	3.1	3.1
Nuclear gas stimulation	AEC	3.7	6.1	7.1	7.2	4.0
Oil shale	DOI, BOM	2.4	2.7	2.6	2.5	2.0
Nuclear fission		283.4	295.2	358.0	412.0	475.4
Liquid metal fast breeder reactor	AEC	144.3	167.9	236.0	269.0	320.0
	TVA			.2	3.0	3.0
Other civilian nuclear power	AEC	108.5	96.6	86.8	98.0	90.5
Nuclear materials process development	AEC	30.6	30.7	35.0	42.0	61.9
Nuclear fusion		37.5	42.2	52.8	65.5	88.5
Magnetic confinement	AEC	34.3	32.2	33.3	39.6	47.3
Laser	AEC	3.2	10.0	19.5	25.9	41.2
Solar energy	NSF			1.7	4.2	12.2
Geothermal energy		.2	.2	1.4	3.4	4.1
	NSF			.7	.7	1.4
	DOI-GS	.2	.2	.7	2.5	2.5
	DOI-BOM				.2	.2
Electrical generation, transmission and storage			1.3	2.2	4.9	4.1
	NSF		.5	1.3	2.4	.9
	DOI		.8	.9	1.0	1.0
	AEC				1.5	2.2
Control technology (stationary sources)				28.6	38.1	47.5
Air pollution control technology	EPA	19.8	17.4	24.5	29.5	21.5
SOX removal	TVA			1.1	3.0	18.0
Thermal effects	EPA	.8	.6	.7	1.0	1.0
	AEC	1.5	1.8	2.3	4.6	7.0
Miscellaneous				6.3	6.9	11.0
Systems and resource studies	NSF			4.4	5.3	5.3
Energetics research	NSF			1.9	1.6	1.7
Interior central fund (part)	DOI					4.0
Total research and development		382.4	419.2	537.4	642.3	771.8
	AEC	326.1	345.3	420.0	487.8	574.1
	EPA	20.6	18.0	25.2	30.5	22.5
	NSF		.5	10.0	14.2	21.5
	DOI	35.7	55.4	80.9	103.8	132.7
	TVA			1.3	6.0	21.0

Agency codes: AEC—Atomic Energy Commission; DOI, BOM—Department of the Interior, Bureau of Mines; DOI, GS—Department of the Interior, Geological Survey; DOI, OCR—Department of the Interior, Office of Coal Research; NSF—National Science Foundation; TVA—Tennessee Valley Authority.

Senator Cook. In analyzing these figures it is interesting to note that \$2.110 billion or 76.6 percent of this total was funded for atomic energy. The remaining sum—\$625 million—was divided over all other R. & D. projects related to energy.

I take no issue with the amount funded for atomic energy as I believe that we will benefit from this important program. I do regret the paucity of funds—\$625 million—which has been shared over the past 5 years by programs related to coal, oil, gas, geothermal, solar, and other systems. We must correct this deficiency. I believe that the establishment of a fund in the amounts suggested will meet this requirement.

SOURCE OF FUNDING

Now let us consider the source of these funds. I again suggest the user approach as was adopted for the successful highway trust fund. However, rather than revenue from the tax on oil, gasoline, and other goods and services placed on the user, I suggest that we utilize the revenue from the assets of the user. In this instance the user is most certainly the public—you and I. And the asset of which I speak is our public land and more specifically that public land which lies on the Outer Continental Shelf—OCS. For many years we have had these assets but we did not consider them to be of any great value because the cost of producing fuel far exceeded the price which it could command in the marketplace.

Today in a fuel deficient market we find that these OCS assets have indeed increased in value. The irony in this increase is that it has come about by an energy shortage, particularly the shortage of oil and gas, which threatens to destroy many of our much more tangible and recognizable assets and reduce our standard of living.

The revenue comes to us through the lease bonuses paid by the energy industry for permission to explore for and produce energy fuels from our public land. The use of funds collected by the Government in our interest from the energy industries for the use of our land would seem to me to be a most logical source of funds for Government-funded R. & D. programs to solve our energy problem. Projections for the adequacy of such fund seem to be most favorable.

I have received information concerning the OCS lease sales alone and request that it be printed in the record at this point.

Senator Ribicoff. Without objection.

[The above-referred-to document follows:]

ENCLOSURE 2

OUTER CONTINENTAL SHELF LEASE SALES

Year	Leased tracts	Acres	Bonus (millions)	1st-year rentals (millions)
1968	197	934,167	\$1,346	\$3.0
1969	40	114,283	112	1.1
1970	136	591,040	944	2.1
1971	11	37,222	96	.4
1972	178	826,195	2,251	2.5
1973 [1]	104	600,000	1,598	1.8
Total	666	3,102,907	6,347	10.9

[1] Preliminary estimates. O & G Journal, June 25, 1973. In addition a lease sale of about 800,000 acres is scheduled for December 1973.

If we take the period of calendar year 1968–72 and the first few months of 1973 we find that $6.347 billion have been collected in lease bonus payment by the energy industry. This is considerably more than was expended for the R. & D. during a similar period. I also remind the Congress that the President has announced his intention to increase by threefold our previous lease sales and has announced one additional lease sale of considerable size for this month. Judging from the acreage involved, the revenue from this sale could well exceed $1 billion. This total sum for this year would be over one-half billion in excess of that required to support the funding for the proposed trust fund.

While the income from the Outer Continental Shelf would be adequate in itself, I would also include the receipts from Federal lease sales and all other sales or grants of development rights of energy sources of Federal lands. In this way, I am convinced that we would have more than adequate source of funds to meet our requirements.

S. 1283

Mr. Chairman, before leaving this subject, I would like to recognize that when S. 1283 was introduced by Senator Jackson as an energy conservation measure, I cosponsored the bill. On review, however, I find this bill makes no permanent requirement for funding, thus leaving it to the Congress to appropriate at any level of funding after the first year or at no level of funding at all. I might digress here for just a moment, Mr. Chairman, and say that I have been told that in 1954, the Congress appropriated several millions of dollars for research and development on coal gasification at a university in the Middle West. Its projections did not work out; its research was behind schedule. And the next time it came to Congress for additional funds, Congress turned it down because it was behind schedule. If we had realized how badly we needed coal gasification and liquefaction at that time, we would not be in the position we are in now. But that project was faced with additional funding from Congress which was not there.

In addition, it fails to contain the very important element of creating a separate agency to manage our total research and development effort and limits funds to specific projects. I might say one that really bothers me is it sets up separate corporations for coal liquefaction and coal gasification, and they are the result of the same efforts and the same type of research and development. A project to produce 25,000 barrels of crude oil a day by use of the utilization of 10,000 tons of coal also produces somewhere in the vicinity of 200 million cubic feet of gas, which is used for the utilization of that facility. That gas is not pipeline gas, it is somewhere in the vicinity of 800 Btu. But the point of it is all you do is correct that facility to produce a higher gas and yield less liquid and you could produce pipeline gas instead of the liquid. So therefore, you just could not conceivably have separate corporations for coal liquefaction and coal gasification because they are so closely related.

Such limitations would defeat the flexibility and responsiveness so necessary in this type legislation. I therefore, Mr. Chairman, cannot support S. 1283 in its present form.

In conclusion, Mr. Chairman, I am encouraged that this committee is conducting these hearings on the vital issue of establishing ERDA

with or without the extra "D" for demonstration in the name but most certainly with adequate provision for demonstration. I hope most sincerely that you will take that extra and vital step of inlcuding a trust fund to insure that the Administrator of ERDA will have available the necessary funds over a continuing period of time to enable him to accomplish the task ahead.

ENERGY CRISIS HAS HELPED US TO UNIFY

Let me close on an encouraging note: The unity of this Nation has been fragmented by events of the past few months. I now see concrete evidence that the people are becoming unified by the impact that the energy crisis is having on them as individuals and on the Nation itself. Let us hope that from the hardships we will be facing this winter, that a stronger, better and a more unified nation will emerge and that by out efforts here that we will have made a significant contribution to this unification.

Senator RIBICOFF. Senator Cook, senatorial courtesy aside, I am very pleased that you came here today. Your testimony was interesting, provocative, and perceptive. May I ask one basic question?

WILL WE HAVE PROCESSED OIL FROM COAL BY 1980?

You come from a coal State where there are large deposits of coal and substantial production. I have assumed that the first alternate source of energy we will develop in this country would be gasification and liquefaction of coal. In recent days, I have been reading a number of articles in the press which have had a caveat, do not expect that we are going to get energy from coal by 1980. Do you share this pessimism?

Senator COOK. Senator, an installation that would produce 25,000 barrels of oil, would require an expenditure of approximately $300 million. It would take approximately 5 years for that facility to be built. It needs an area of approximately 1 square mile and an absolute minimum production of 10,000 tons of processed coal a day. So you are talking in terms of somewhere at least 12,500 tons of coal production a day.

In order for that facility to pay out on a demonstration program, either for the Federal Government or for private capital—and there is discussion at the Office of Coal Research that you would do this on a basis of $200 million from the Federal Government, $100 million from private facilities—you would need a 50 to 100 millions of tons of coal as a resource. There are a few locations where such facilities could be built. It would be difficult, but not unreasonable, to build them mostly in eastern or in western Kentucky. When one gets in eastern Kentucky, it is difficult to find a square mile of comparatively flat land. We have received from engineering firms very detailed information that it would take in the vicinity of close to 5 years before such a facility could be on the line and start producing either liquid or gas.

INCENTIVES FOR PRIVATE CAPITAL

Senator RIBICOFF. If there were guaranteed incentives or were sufficient incentives for private capital to get a fair return on their

investment, do you see private capital coming into this breach, or do you believe it will take a combination of private capital and Federal funding to do this job?

Senator COOK. Mr. Chairman, I think it is going to take a combination of both.

I might say if you really want to solve this problem that out of this trust you could actually build refineries, pipelines, or whatever is required. Such projects could be backed by the private sector and the Federal Government and both will be paid back, just as we did in World War II.

Senator RIBICOFF. That is the point. In other words, if we are going to take and assure continued research that will not be terminated, and if we need these huge sums of money, then will you not be in a position to consider whether this trust fund that you are talking about could be used for both purposes?

Senator COOK. Absolutely.

Senator RIBICOFF. Do you believe that there would be sufficient income generated from your proposal to take care of the next 10 years of funding for both research and capital contributions?

Senator COOK. Well, may I say, Mr. Chairman, if you are talking about $2 billion a year, it takes $300 million to build one refractory that will produce 25,000 barrels of fuel a day. That $300 million will be expended over 4 to 4½ years, with $100 million contributed from the private sector and $200 million from the fund. I think you will agree that $200 million is a very small percentage to be projected over 4½ years to build such a facility and would not be an unacceptable drain on the trust.

Senator RIBICOFF. Let me ask you again from your own personal knowledge in your own State of Kentucky, do you see the acceleration of the production of or the mining of coal, or do you think that you have reached your maximum capacity there?

NO FUEL TO INCREASE PRODUCTION OF COAL

Senator COOK. Mr. Chairman, we are now in a problem, We can have acceleration production of coal if we have the fuel to accelerate. We have a number of facilities in our State that do not even have the diesel fuel they require to keep in operation.

Senator RIBICOFF. Now, that is ridiculous.

Senator COOK. The production is there, Mr. Chairman, if that is what you are asking.

Senator RIBICOFF. In other words, you find yourself in the anomalous position of having your fuel supplies cut off that could increase your production of coal?

Senator COOK. That is correct.

Senator RIBICOFF. We will be holding hearings tomorrow on S. 2776, to set up FEA—Mr. Simon's agency. I discussed that with him on Sunday. One of the assistant administrators in FEA will have the sole duty to break the bottlenecks to supply the resources, whether it is fuel, or material, or whatever is needed, to keep the flow of other energy sources going. We have all these ridiculous bottlenecks that must be opened up.

Senator COOK. That is correct.

May I say, Mr. Chairman, and your previous witness talked about the utilization of oil shale to produce oil and the fact that we have such shale in abundance. If you think we have problems with strip mining in eastern Kentucky and West Virginia and eastern Tennessee right now, you have not seen anything of the type of stripping which will be necessary to utilize oil shale to produce oil. The amount of oil shale that it takes to produce a barrel of oil is much greater than the amount of coal it takes to produce a barrel of oil. You are literally going to have to just chew and chew and chew the terrain to produce oil from oil shale.

Senator RIBICOFF. I like your trust fund concept of financing both the research and the development of new facilities. Again my appreciation.

Senator Percy?

Senator PERCY. I would rather waive and come back as soon as I finish Senator Cook's testimony.

Senator RIBICOFF. Senator Chiles?

OFFSHORE EXPLORATION

Senator CHILES. I am also pleased with your concept of trust funds. I have introduced some legislation in that regard myself. I think now—perhaps at one time when we were seeking this exploration, we were looking for dollars as well as oil. But now, I think that certainly our concentration should be in the offshore exploration and trying to find out what we have in the way of energy there. It seems kind of ridiculous to me that now that we are stepping up sales on the offshore tracts and we know that there are going to be considerable dollars generated. This money is just going into the general treasury. It is kind of registered as unaccountable funds. Congress really does not see what happens to it the same way that we do with budgeted funds.

I think also, we find that as it is going this way, certain decisions are not weighed the way they properly should be weighed between drilling in a particular place at particular times in consideration of the kind of knowledge that we have in regard to what that will do to the environment. When you have those free dollars sitting there and OMB ultimately making the decision in a dispute between Interior or the Department of Defense or Interior and EPA, it seems to me, you have loaded the deck. You have put a joker in it when you are going to say OMB will get billions of dollar free money out of that sale. If this money went into a trust fund, you are doing two things: You are providing the funds as you set forth your development, for research, for trying to get better extraction and everything else that the money could be used for; at the same time, you are allowing the system to work more properly in its checks and balances as to the weighing off of the need for energy as opposed to whether you have done the proper research and have the proper information. So I think that is another major factor.

Senator COOK. May I say to you, Senator, I have sent both of these bills downtown and they object very strenuously to the trust fund aspect. I could not disagree with them more. I could not disagree with either the White House or the OMB more. These are resources that belong to this Nation and therefore, they belong to its people.

We now find ourselves in a situation where we have to move ahead with decision, with an absolute commitment, and that commitment can be made if the finances are there and the finances can be maintained. And for OMB to take this position is shortsighted. It does not, apparently, realize the significance of the problem, nor does it really want to solve it.

BIRTHRIGHT OF U.S. CITIZENS

Senator CHILES. Well, it seems to me, we would be selling off sort of our birthright at the same time that we are not really solving the problem, and then the offshore oil is going to be gone and what have we done toward developing atomic or solar energy? We have sold sort of the luxury that we have of having a birthright there in regard to the fossil fuels.

Senator COOK May I say, Senator Chiles, that this research and development and demonstration agency or research and development agency must also develop improved offshore recovery techniques as a very, very important facet of their research. Are we at the end of the fossil fuel age in relation to its ability to produce and not give us a crisis? We have to look to those sources and say that we realize that the end is down the road and we are going to be prepared for this eventuality rather than to panic when it does occur.

COMPENSATION FOR THE OFFSHORE STATE

Senator CHILES. Another thing that I included in my bill perhaps is conventional, but at the same time, I think it should be considered and that would be that some portion of those assets, where there is offshore drilling, should be returned to a trust fund to the States off whose shores you are drilling, because they have problems also in regard to what happens if there is a spill. What they do to the change in their environment that is occasioned by this? I do not know what that portion should be, but I have a feeling we now want to drill across the Atlantic coast, that this would certainly make it a little more palatable to some of those States with some of the risks they know that they are running, the same way it would be to the gulf area if there would be some return, again to a trust fund—I do not think it should go to the States as free money.

Senator COOK. Senator, you and I have discussed this. As you know, I agree wholeheartedly with you. I think a percentage of this trust should be directed to specific environmental research purposes in the respective States that are affected by drilling; whether they be periphery States or whether they be other States of the Union that are not so located.

Senator CHILES. I would agree with that.

Senator RIBICOFF. Senator Nunn?

Senator NUNN. A couple of questions.

I, too, enjoyed your testimony, Senator Cook, and I thought that you brought up some excellent points.

MORE ON THE CONCEPT OF A TRUST FUND

On the trust fund idea, I understand you would have this trust fund set up so the Administrator could spend as he saw fit during

each fiscal year and it would not be mandatory as to how much is expended in 1 year. Is that right?

Senator COOK. Senator, if you wanted to submit a program to a particular committee in the House and Senate relative to research and development to include a dollar figure, I would have no objection at all. I think that can be easily worked out. But I think there has to be a degree of freedom in the program to permit long range planning. We must realize that one of those years during that 10-year period, you might be spending $4 or $5 billion. We have to be prepared to really hit that checkbook on that year and you may go well above the $2 billion figure. The only way that you can protect the stability of that is to provide that degree of freedom.

Senator NUNN. I think you agree with the basic thrust of the testimony yesterday that the first year funding need not be as high as in a later year.

Senator COOK. But I noticed in testimony yesterday that it would be well in excess of $1 billion the first year.

WHERE DOES THE MONEY COME FROM?

Senator NUNN. One other question on the trust fund. I think it is apparent that we are going to have a commitment to the overall R. & D. effort perhaps more than we have ever spent on any project. But when you have had $2 billion a year coming into the general fund and then you suddenly take that money and put it in R. & D., you either have to cut $2 billion out of expenditures or raise $2 billion in taxes or put $2 billion more into the economy at the risk of an inflationary trend. Therefore, we are going to have to bite the bullet. That $2 billion is not going to pop out of the earth. That is my point——

Senator COOK. Senator, may I say in all fairness, the bullet has been bitten. The Jackson bill provides for $2 billion a year to be appropriated by Congress. The President of the United States had called for $2 billion a year. When he called for $2 billion a year, he did not ask for increased taxes to do it. All we are doing is utilizing the funds of the users to develop a program that is far behind schedule and we want to sanctify that program and see that it has the capability for doing it by impressing a trust on those funds rather than just saying they should be out of general fund revenue every year.

Senator NUNN. I agree with you the approach being taken by the administration and everyone else has the same drawback, but that still gets to the same question. The bullet has not been bitten by anybody yet. Whether we get the money from a trust fund or by going into the general fund, we have to do it by three ways as I see it: We have to increase taxes $2 billion, cut expenditures $2 billion, or we have to say to the people of America, we are going to add to your inflationary pains along with your energy pains.

Senator COOK. Senator, that really does not follow, because as I stated in my statement, from 1970 to 1974, we spent $2.753 billion on research and development. So therefore, in a 4-year period, we spent almost $3 billion. Therefore, you are not really talking about new money, you are talking about increasing the amount of money that you have already appropriated for research and development. So at least, you do have a history of a setoff against that.

Senator NUNN. About $1.2 billion would be your net increase.

Senator COOK. That is right.

Senator NUNN. I am not asking you to solve this problem, because I think it addresses itself to everyone. But I do think while we are talking about this and while we are trying to be candid and honest and tell the American people what we are going to do, we are going to have to face the fact that we are going to have to spend more money one way or the other, from general funds or trust fund, and we are going to have to get it from the same place we have been getting it from—the American people or their assets.

I think while we are addressing the problem, we also ought to go ahead and be candid that at some point, we are going to have to increase taxes or cut out important programs, thus causing pain and suffering to those who are the recipients. I want to make that point.

Senator COOK. This is what one calls reorienting priorities in the United States. One of the priorities that is absolutely needed in the United States now is a crash program of research and development in the energy field.

Senator NUNN. I just hope that for a change, while we are reorienting our priorities, we go ahead and face facts now instead of unloading more inflation on the American people, which is what we do every year.

Senator COOK. I cannot argue that point.

NEW JOBS IN ENERGY DEVELOPMENT WILL BOOST THE ECONOMY

Senator RIBICOFF. I would like to add a footnote to this colloquy. There is no question the energy crunch will lead to a dislocation of our entire economy with increased employment. What you must take into account is when you go into research and development and also the production of additional alternate sources of energy, you will be increasing the national wealth and jobs. I do not know of any other program that this country could undertake to give our economy a great boost. We are talking about synthetic fuels of any kind which would probably take an expenditure of about $50 billion, what we spent for space to put a man on the Moon. What we will get for that in the long run will help our economy so substantially that the Nation in every facet of its life will be the gainer.

I am deeply impressed with your concept of the trust fund, which is missing from the administration proposal. I would appreciate if you would make your staff available to work with my staff, the staff of this committee, to see if it were possible to marry those concepts.

Senator COOK. Absolutely.

Mr. Chairman, may I say that your remarks relative to increasing the productivity of the United States are so true. A major corporation on the New York Stock Exchange announced that it was acquiring a lease on 500 acres in the county next to the county in which I live. I discussed this with them and stated that I hoped it really didn't give any indication to the pecple in that county that they are going to start building a factory tomorrow. I was concerned because the gas company down there could not connect them, could not give them any service. The point I am trying to make is that the productivity of that factory would be a more obvious and reliable truism if, in fact, we had the availability to supply that plant with the fuel it needed.

It seems to me, Senator Nunn, that as we produce more energy, we are are going to produce more industry and many, many more dollar bills for this Nation.

Senator RIBICOFF. Senator Percy?

Senator NUNN. I would like to have one other question at some point.

Senator PERCY. Please go ahead.

DEMONSTRATION PROJECT

Senator NUNN. I think the demonstration project is awfully important. I hear more and more people say not just on energy but in other fields, we do continuous R. & D. but we never put it into practice. You are saying in effect that we ought to make sure that whatever technology we develop with this huge expenditure, we also have a commitment to put it into effect at the same time—not just with demonstration project, as I understand it, but with actually producing plants.

Senator COOK. I mean producing plants on a demonstration basis, Senator. For instance, I see the kind of refractory I talked to you about that would produce 25,000 barrels a day. For a 1-, 2-, or 3-year period, that would be a demonstration plant while it was producing that amount of fuel. We have got to do it on this basis, because we have to make sure that when we make these kinds of investments, we can sell this to the producing segment of our economy and we know they are going to work.

Senator NUNN. Fine. I think that is an excellent point, Senator Cook. I appreciate your testimony.

Senator PERCY. Senator Cook, I would like very much to insert your testimony into the Congressional Record so that it could be read by all of our colleagues tomorrow. We will be considering S. 1283 on the floor very shortly.

Senator RIBICOFF. As I understand it, it is the second item of business on the calendar today. I would gather that we will get to it today.

Senator PERCY. I imagine we will not finish it, but if you will not object, I would like to put your statement in the Congressional Record.

Senator COOK. May I say it is my intention to submit an amendment and to debate on the floor this amendment that takes out of my bill the establishment of the trust fund and——

Senator RIBICOFF. I think in all fairness to Senator Jackson, my understanding is that when he put in his bill, there was no ERDA in the works.

Senator COOK. That is correct.

ERDA DEFICIENCIES

Senator RIBICOFF. Senator Jackson realizes that there must be a mechanism to trigger what he seeks to achieve. He recognizes that ERDA is the overall mechanism. He is a cosponsor of ERDA with reservations. He believes that ERDA has basic deficiencies which he would like to correct or try to modify. I would imagine many of the thoughts he has in mind are similar to yours. So in all fairness to

Senator Jackson, at one time he contemplated marrying ERDA and his proposal, but he has agreed not to do so.

Senator Cook. I agree and I have talked to Senator Jackson on many occasions on it.

Senator Ribicoff. His bill would go on its own and ERDA would be the mechanism once it is established to put into effect the Jackson proposal.

Senator Percy. In all fairness to Senator Jackson, I was not in the room yesterday when he made an opening statement, but would you not interpret that opening statement as opposing ERDA?

Senator Ribicoff. No, I did not. I think his opening statement indicated that while he believed in the general thrust of ERDA, there were factors in ERDA that he thought had to be thoroughly examined. I think that statement has been made by others.

As far as I am concerned, I believe we should move as fast as possible on ERDA, but I would gather that there will be other people with other ideas. I think Senator Javits indicated that he wanted to make sure that what we were achieving could do the job on a long-range basis and it was not just being set up for the present emergency. Otherwise, it would be a disservice to the whole concept.

I believe the thrust of Senator Cook's testimony is the fact that we should be thinking of a permanent organization that can do the job.

Senator Cook. That is right.

Senator Ribicoff. That is why Senator Cook, before you came into the room, Senator Percy, emphasized the problem of the trust fund to be sure that the funds would be in there to carry out what we are seeking to achieve.

Senator Percy. I feel Senator Cook, as a cosponsor of S. 1283, is now carrying out the ERDA concept we talked about yesterday. I think when you do take into account new factors, it would be a great mistake for Congress to act hastily, just because it is an energy bill and Senator Jackson is behind it. I think we ought to think very carefully that now there are new factors, new legislation. We have new things to take account of, and I for one intend very vigorously to try to point this out and not let S. 1283 just rush through tomorrow. I think your testimony on it pointing out one obvious deficiency that you felt should be met is very important. So I will put your comments in the Congressional Record today if you will not object.

Senator Cook. Thank you very much, Senator.

CONTINUOUS FUNDING

Senator Percy. I also would like to comment on the necessity in this field for the steadiness of funding. I think you are absolutely right. Having been on the Space Committee my first 2 years in the Senate, I really felt the erratic nature of our appropriations process for space, gyrating from the highest, $6 billion, down to a low of about $3 billion, in which people were laid off, then hired back. It was a lot better to try, as we did for several years, to give them less funds but steady funds. Because having run research programs, I know the terrible difficulties. These are long-term problems, and the tragedy we have in wasting funds and not being able to count on them is the reason I would like to inquire as to how much we can count on the funds

under the trust fund concept. The reserves for the OCS leases now go to the Land and Water Conservation Fund, up to $300 million per year. Does your bill take into account diverting funds from the Land and Water Conservation Fund, or do you——

Senator COOK. Not at all, Senator. Three hundred million dollars out of this fund is not going to hurt that fund at all nor would it hurt in reaching the figure of $2 billion. It is estimated that with the acceleration of sales, that we will sell in the next 4 to 5 years and longer upwards of $5 billion a year in leases. So therefore, I do not think that we will tamper with the $300 million. I would only suggest to you that you could put the $2 billion in this fund and you could still have funds for general fund revenue.

Senator PERCY. Would you foresee from the revenue that you have provided from various sources at any time any possibility that there could be less than $2 billion in the fund after they are supplied? If so, where would they come from?

Senator COOK. Senator Percy, based on our research just of the sales in the past, which have not been on an accelerated basis, and Lord only knows that we have areas that we have not even considered putting out or made available for bids on a bonus basis, that we are really just scratching the surface in OCS. As a matter of fact, probably in many areas of federally owned lands throughout the United States, we are just scratching the surface.

AUTHORITY TO EXPEND FUNDS

Senator PERCY. I would like you to answer for the record, because I think many of our colleagues would be interested in your response. In the testimony, you indicate that ERDA would have total authority to expend funds from the trust fund. There will be some who will say that this is the authority of Congress and should not be taken away. How would you reply to those critics?

Senator COOK. Senator, I have no objection if the proposal for research and development by the Administrator be submitted to the respective committees of the Congress that this committee may feel would be the proper ones. I just felt that in this situation that we are in, we must give a rather remarkable Administrator the ability to move ahead and not be hampered, but if we establish that trust, then I must say that the reporting would be a much more palatable thing. We would be buying this research and development, or we probably would be saying that he might accelerate one field or another. I doubt very seriously whether we would hold such an administration back.

SUPPOSE WE SHOULD HAVE EXCESSIVE FUNDS

Senator PERCY. We have covered whether there would not be enough funds. What will we do, and I have not read the legislation in detail, what will we do if we have excessive funds? Instead of $2 billion, we could run $5, $6, $7 billion. Does the bill provide for the use of those excess funds or turning them over to general receipts?

Senator COOK. You mean in the trust?

Senator PERCY. Yes, in the trust.

Senator COOK. Actually, if there is an excess in funds, Senator, under the bill we have introduced, they are invested in Government

obligations. That agency can really increase its revenues relative to research and development and obviously, at any time, the Congress could see whether there are sufficient funds. If the fund grows too large, obviously, you could reduce it in the same manner as you did with the highway trust.

Senator PERCY. That is why, for those of us who really feel the desperate need for mass transit, we see mass transit starving when we could have done something years ago about it at much less cost than now.

Senator COOK. Senator, if you do not have the energy, mass transit is going to starve a lot more.

Senator PERCY. But we see unspent funds in the highway trust fund. Would it not be wise to make provision for the diversion of excess moneys in the trust fund?

Senator COOK. I have to say to you that we are going to start off on an awfully shaky basis if we feel that $2 billion a year ought to be spent on research and development and demonstration programs and provide a mechanism by which we can already start taking its funds away from it.

Senator PERCY. Suppose you do accumulate $5 billion year in and year out for 10 years. What are you going to do with that?

Senator COOK. Even if you take in $5 billion, you are only going to, under this bill, utilize $2 billion of it on an annual basis.

Senator PERCY. In other words, the bill does clearly provide that you only take $2 billion out of it and all the rest goes into the general fund?

Senator Cook. That is correct.

Senator PERCY. That is what I wanted to clarify.

Senator RIBICOFF. Thank you very much.

Senator COOK. Thank you, Mr. Chairman.

Senator PERCY. I had not finished, Mr. Chairman.

Senator RIBICOFF. Senator Cook, would you return, please?

Senator PERCY. Because of your background, I would like your comments on two other areas, increasing supply and reducing demand. What can you tell us about the potential for going deeper for coal, taking into account safety, and what is your observation and policy on strip mining? These are the questions constantly being put to us now. How far can we go to increase the supply of coal?

ENERGY SUPPLY

Senator COOK. Senator Percy, first of all, in relation to the supply, I would like to have an opportunity just for my own State to produce what figures I can for you relative to the availability of coal and the untapped resources of coal.

STRIP MINING

Relative to strip mining, it has always been my position that there have got to be very, very strict regulations in regard to stripping coal. I must say in all fairness, we have had some very, very poor operations in my State. We talked about slopes and we talked about other problems in the development of strip mining bills that we have had before us. Yet I can take you to western Kentucky where the

slope is less than 5 percent. Yet by reason of very, very bad, practices in the past, the landscape is just horrible.

I might say to you in all fairness, Senator Percy, part of the research and development that could be done within this agency would be the development of capping coal underground and burning that coal underground at a regulated rate so you can take the gas directly out of the ground. That certainly has been discussed. You certainly would not have to destroy hillsides and valleys in my part of the State. You would feed that gas directly into a central system. If it needs to be methanized so it can reach a burnable and a salable Btu, that step would have to be taken. However, there is a great deal of study that has already been done relative to gasification in place.

GASOLINE RATIONING

Senator PERCY. Finally, on the demand side, what is your own feeling as to whether we are going to have to have gasoline rationing, or whether the unity of purpose that you eloquently described is going to be such that the people of this country will respond to a national need and will cut down demands sufficiently so that we will not have to go to a system that we all know has so many flaws in it, arbitrary rationing?

Senator COOK. Senator, I wrote a letter to Governor Love yesterday relative to a discussion I had with a good friend of Senator Lawton Chiles from Florida. I proposed an idea to him and I said that it was not original with me, but that I thought it had a great deal of merit. I suggested that we take a 6-day week and issue decals or whatever to the people to put on the automobile windshield to designate that car as a Monday, Tuesday, Wednesday, Thursday, Friday, or Saturday car. Whatever particular decal is on that car, that car cannot be on the road that day. That means that one-sixth of all the automobiles will not be utilized in a given day. Every automobile in the United States will not be used on 1 day during those 6 days. If there are 107 million vehicles, you will have somewhere in the vicinity of 15 million vehicles off the road on 1 given day and that the Nation will save $12^1/_2$ billion gallons of gasoline a year.

Senator PERCY. And presumably, the system has flexibility. If you had to, you could cut it to 5 days a week.

Senator COOK. If you had to, you could. But I might say to you, Senator, I have very serious misgivings about rationing. I wish we would try a program before we ration.

I would only say to you, that when you have a great big MON on your windshield and you drive on Monday, it is going to be easy for a policeman to find you.

Senator PERCY. I might say I find that very interesting. I thank you.

Senator RIBICOFF. Senator Percy, my apologies.

Senator PERCY. Not at all, Mr. Chairman.

TESTIMONY OF S. DAVID FREEMAN—Resumed

Senator RIBICOFF. Mr. Freeman, to try to cover our witnesses, may I have the privilege of submitting to you a written series of questions for your response within a week or so?

Mr. FREEMAN. Surely, Mr. Chairman.

[The following material was subsequently received for the record:]

Question No. 1. You propose that anyone now in a position of responsibility for energy research and development be foreclosed from assuming the position of Administrator of ERDA. Do you think we should write such a requirement into the statute, or leave the decision to the committee which will consider the President's nomination for the past?

Answer. I think it could best be expressed in the legislative history of the bill, possibly in committee reports as guidance to the President that the new Agency should be new in fact as well as in name.

Question No. 2. I am not sure of your position on transfer of the military applications program from AEC to ERDA. Do you advocate transferring it now, and then allowing the Administrator to make a later recommendation on its final location?

Answer. I don't believe enough preparatory work has been done to effect an immediate transfer without risking damage to the program and loss of efficiency and morale. Yet there is a great concern about diverting ERDA's attention and focus by leaving it there. I therefore recommend a requirement that the Administration make a recommendation that could be implemented based on his first years experience.

Question No. 3. In your statement you express concern that an ERDA "divorced from energy policy-making and real operational problems, could wither and get off the track over the years." You suggest a Department of Energy. Perhaps that will be the eventual solution, but for now, how can we tie ERDA securely to the policy formulation and implementation process?

Answer. I believe that a Council on Energy Policy along the lines of S. 70 should be established that could perform the job of tying ERDA, and other agencies securely to policy formation. Such an umbrella group, not bogged down in the day to day operating problems of the new Emergency Agency and the regulatory agencies could serve that essential function. Based on experience in the next year they might recommend consolidating ERDA with other executive agencies into a Department but perhaps not. But there would be a tie-in.

Question No. 4. Your statement says we must recognize that we are just beginning the reorganization needed in the energy area. What other reorganization measures should Congress consider?

What is your view of the Administration's proposal for a Department of Energy and Natural Resources?

Answer. Basically there are three additional areas. One is the creation of a policy-making Council at the top of the pyramid of agencies to pull together a national energy policy reflecting inputs from all agencies of government. The other is the possibility of consolidating all the executive energy agencies into a Department of Energy and third is a basic reorganization of the regulating agencies—the FPC, the new NEC, SEC, etc., to reshape them to meet the problems of the 1970's and beyond. While I favored a Department of Natural Resources three (3) years ago, I now believe that the energy activities of government are large enough and important enough to justify a Department and that Interior should be reshaped to become a Department of Natural Resources. However, experience in the next year may dictate a different course.

Question No. 5. How do you see the role of private industry in these research efforts to find new energy sources?

How much money should they invest in research?

Answer. There is a large, very large role for private industry. Their role should increase as a techology comes closer to commercial reality. Private companies will be building the shale and synthetic coal plants and they need to be heavily involved in the last steps of development. That's why I suggest that the government contract for shale oil and synthetic oil and gas rather than financing all the demonstration plants with federal funds. With a guaranteed market in which they can make a profit there is reason to believe that industry could supply over the next 10 years several billion of the 20 billion that will undoubtedly be needed. Furthermore the electric and natural gas utilities should invest at least one (1) percent of their revenues in research and development, and this would mean several hundred million per year. The electric power industry deserves credit for beginning such an effort but it needs to be enlarged.

Question No. 6. One of the greatest problems facing the nation is the potential conflict between the need for energy to run our economy, and the need to preserve

a healthy environment. Can we produce the necessary energy without seriously damaging the environment?

How?

Answer. Yes by cutting out much of the waste in consumption over the next few years and at the same time expanding supply by learning to burn coal more cleanly, mining it from areas where the land can and is reclaimed, getting more oil from existing reservoirs, drilling where its safe to do so, resolving the problems of nuclear power and launching strong programs to harness the sun and develop other cleaner sources. Any production of energy causes some damage but I believe we can avoid serious damage. For the long term there may well be limits in the consumption of energy because of climatic changes and for that reason shifting to a less energy intensive economy may well be desirable.

Question No. 7. You suggest that the federal government could promote private investments in extracting oil from shale by agreeing to buy the oil.

As part of this would you guarantee the investors a minimum price for their oil?

How much do you think this would cost the federal government?

Should we include specific legislative language requiring the administrator to engage in such programs and provide the necessary funding?

Answer. I would invite competitive bids that were quite detailed as to performance and environmental protection plans and award contracts to the lowest bidders that had environmental protection plans acceptable to EPA. The contracts would be for a long enough term to pay out the investment in the plant. The bids may come in higher than the current market price for oil but the cost to the government should be far less than if it financed the plant itself. In fact over the 20 year life of the plant the oil might even save the government money. The bill's language I believe clearly permits such arrangements, and the legislative history should cause the Administrator to explore this option on technology that is near to commercial feasibility. The funding would I believe come in separate legislation.

Question No. 8. You suggest that in some instances ERDA should acquire technology already in existence in the private sector rather than developing it itself. Should anything be added to the legislation to assure that ERDA will have a chance to learn what technology private industry already possesses and to obtain use of such knowledge when useful to ERDA's overall mission?

Answer. I believe the best way to handle this would be by inviting competitive bids on the government purchase of the output for any demonstration project before the government funds it themselves. ERDA should have authority to find out what research industry is undertaking subject to keeping trade secrets confidential.

Question No. 9. You are obviously worried that nuclear energy will dominate the new agency. However, judging from the newspaper reports of Chairman Ray's recommendations to the President and her testimony yesterday, it appears she has proposed a balanced program of research and development. Does this lessen your fears in this area?

Answer. Actually the new budget underscores my fears. The proposed budget as I read it is dominated by nuclear power with over 50 percent of the total. Only 2 percent of the funds are for solar energy, about one-fifth of what the solar experts recommended. The program for more efficient energy consumption technology is very small in comparison to the opportunities. I am more concerned about a balanced program than ever.

Question No. 10. President Nixon has proposed that the U.S. become energy sufficient by 1980. Do you think the achievement of this goal is feasible?

What would be the dollar cost of reaching it?

What would be the social and environmental cost?

Is it in our national interest to do it?

Answer. I don't think it is feasible. Nor is there any reason to cutoff imports from friendly countries like Canada, Venezuela, Nigeria, or Indonesia unless we can produce the energy at home cheaper—and we can't by 1980.

The only way to achieve self-sufficiency by 1980 would be to scrap the air quality laws and launch a furious assault on the earth to dig and drill regardless of the damage inflicted. Even so we may not be able to switch to coal, and find enough petroleum fast enough. Conservation of energy combined with increased supply is an environmentally acceptable way can balance our energy budget by 1980 without importing Arab oil in quantities that could not be replaced in an emergency. We should be importing as a matter of choice and with backup reserves for emergencies.

But it is contrary to our national interest to make self-sufficiency-energy isolation—our national goal.

Question No. 11. You suggest that the legislation require creation in ERDA of a special office to review the many intentional and unintentional impacts of new technologies. What kinds of impacts did you have in mind?

How can we be sure that the research ERDA undertakes will lead to results with the most favorable impact and that we avoid spending money on research leading to undesirable impacts?

Answer. I am speaking of the impacts which are commonly bunched under the heading of technology assessment. They include impact on the environment, on the ability of individuals to make choices, on our lifestyle, and a broad range of unforeseen results, most of which would probably fall under the broadest definition of the word environment. The Congress has recently established an Office of Technology Assessment that could oversee this work. An office such as I suggest in ERDA with adequate funds (1 percent of the budget) could help shape the R&D for the benefit of mankind.

Question No. 12. One of the most important issues in the bill is the NEC's regulatory impact on ERDA. The present bill permits NEC regulation only at the demonstration stage. You propose that NEC be given an advisory role with respect to earlier phases of research and development. But would it be unwise to give NEC authority to regulate test reactors?

Existing and future uranium enrichment plants?

Nuclear fuel reprocessing facilities?

Answer. I believe it would be unwise not to provide for some independent evaluation of the safety of all nuclear facilities that would be subject to licensing if owned by a non-federal entity. The public health and safety and the safety of ERDA employees really requires such an independent evaluation. The problems that have arisen at AEC facilities in the past supports the need for outside, independent evaluation.

Question No. 13. One of the methods discussed for increasing oil and gas production is perfection of secondary and tertiary recovery technology. Could you please describe the technology involved in both of these methods, and in the case of tertiary drilling, please indicate how much research and development money it will take to perfect the technology?

Answer. The terms secondary and tertiary recovery refer to technologies for enhancing the quantities of oil recoverable from oil deposits in place. The terms are relatively imprecise and cover a spectrum of specific technologies. Secondary recovery generally includes the use of water flooding and pressure maintenance. It has been used widely for the past several decades, and has been responsible for reaching the current recovery rate of about 32 percent. Since this is a well used commercial technology little or no R&D is required to perfect it.

Tertiary recovery is frequently defined as any technology beyond secondary recovery. A wide variety of approaches have been suggested. They generally fall into three groups—surfactant, miscible and thermal processes. The object of all of them is to sweep the remaining oil from the formation toward the well. Surfactants modify the properties of water so that it will mix easier with oil while miscible floods use other hydrocarbons which do mix with oil to sweep out the oil. Several of these processes have been tried at the pilot level but they have not been demonstrated on a commercial scale. The thermal processes are aimed at heavy oils which are too viscous to flow at ambient temperatures.

Fireflooding which actually burns some of the oil in place to heat the rest, and steam techniques have been used in a limited number of commercial projects.

Industry has been conducting R&D in tertiary recovery but at levels not sufficient to achieve its promise on a rapid time scale. Economics and legal problems with joint R&D have both held this technology back. AEC Chairman Ray's program outlines a modest effort (about $70 million over 5 years) in this area. Greater funding is needed to do the job but much of it should probably be provided by the industry. We are presently studying this question to find the appropriate mechanisms for advancing the commercial application of this technology.

Senator Ribicoff. There was one subject that I would like to have you talk about. That is the use of our tax laws for the economic and social purpose of energy consumption, conservation, production, development here at home and abroad. Would you care to comment?

TAX REFORM FOR PRODUCING NATIONS

Mr. FREEMAN. Yes, Mr. Chairman. I was thinking of that subject as Senator Nunn and Senator Cook were engaged in a colloquy about where to find the money to support this research and development. I was reminded of the testimony before the Finance Committee and your own questions at that hearing. Today, under the tax laws, we are providing incentives that cost the Treasury between $1 and $2 billion for people to drill in Saudi Arabia and other Arab nations and foreign nations. It is almost unbelievable, but the tax laws as they are administered today provide a depletion allowance and a dollar-for-dollar writeoff against U.S. income taxes for dollars paid to the producing nations. If we are really interested in sharpening the incentives for domestic production of energy and finding new money to pay for the research and development, it seems to me that that particular item certainly deserves the attention of the U.S. Congress. I am speaking only personally on this matter based upon my own extensive experience in the energy field over the last 10 years, but it is hard for me to dream up a plausible rationale for continuing major tax incentives in nations that have a boycott on the flow of oil to the United States and who are saying that they do not intend appreciably to increase production for their own economic purposes once the Middle Eastern situation is settled. It seems to me that it is time that we accepted them at their word. The producing nations, many of them have small populations and have no way to absorb the quantities of funds that would be generated by the scale of production that we had contemplated that they would engage in. They are also finding that they can make less and sell at higher prices. That is one area for tax reform.

It seems to me also that we have the potential for greatly enlarging the production of oil from wells already drilled through secondary and tertiary recovery of oil. This would be the most environmentally superior and secure source of energy that we can find.

Senator RIBICOFF. How much energy do you think we can get from secondary and tertiary sources?

Mr. FREEMAN. Over the next 10 years, I think it is reliably estimated that we could double the proven reserves of oil that we have. We have around 30 billion barrels of proven reserves. I think it is reliably estimated that with sufficient incentives, and it would require additional incentives because getting the additional oil is much more expensive, it is possible to increase the rate of recovery, which is now around 32 percent, to something between 40 and 50 percent depending upon the degree of optimism. Such an increase in percentage would bring another 30 billion barrels of oil into production.

INCENTIVES THROUGH TAX LAWS

The tax laws could provide a sharp incentive directed specifically for secondary and tertiary recovery. I think it would be more effective than raising prices, because prices of oil could go down. Also, if you give the oil companies an increased price from all the oil, they get a big windfall profit on the oil they are already producing if you raise the prices high enough to cover the cost of increased secondary and tertiary recovery. So here is an area where I think the tax laws could provide a sharp tool to increase production.

It seems to me also that if we look at where we can increase our energy production in 1975, 1976, and 1977, we look at our resource of coal. I am not speaking of coal as gas or oil. We have not time to do that and build the plants necessary. I mean to burn coal as coal. There, I think, lies a major source of filling the gap caused by the lack of flow of oil from the Middle East. And there, I think, the Illinois Basin provides us with billions of tons of coal readily available for strip mining if we have reclamation laws with teeth in them that are enforced. The land can be reclaimed in the rolling country.

The point of my suggestion is that we should seriously consider a tax on oil and gas used as boiler fuel, not only by utilities but by large industries. Then those funds could make available as an investment credit or some sort of rapid depreciation for industries that switched from oil and gas to coal to help them pay for the pollution control equipment and the new boilers that will be needed. This is the kind of program, with the priorities for steel, for new draglines to mine coal for the coal-burning boilers, that could be perfected. This is the kind of program this country has to launch.

SECONDARY AND TERTIARY SUPPLIES

Senator RIBICOFF. How long would it take to get the secondary and tertiary source of our present oil supplies flowing into market?

Mr. FREEMAN. It would happen not in a flood of oil, but over the next 10 years I would imagine it could result in several million barrels a day of increased production in this country. If you think of the North Slope of Alaska having a reserve of 30 billion barrels, and we are thinking of producing 2 or 3 million barrels a day from that resource, I think the increased secondary and tertiary recovery could, over the next 10 years, add a couple of million barrels a day to our supply, which would be significant. It would be, you know, as much as we would be getting from the North Slope.

We can increase coal production and burn coal as coal to give us the equivalent of perhaps another 1 million or 2 million barrels of oil a day if we use that coal in plants that now use oil and gas.

SMALLER CARS TO CONSERVE FUEL

We also can do an awful lot in the way of true conservation if, through the tax laws, we give Detroit some marching orders that this country needs automobiles that have better mileage. And we can, over the next 5 or 6 years, turn over the stock of cars so we have an average mile per gallon per car closer to 20 rather than 12, such as we have now. A combination of all these things will help enable us to balance our energy budget in the years ahead. No one thing will do it. But it seems to me that, as to the research and development side, and I have devoted a lot of years of my life to that, we are kidding ourselves and fooling the American people if we think that program is going to give us help in the 1970's or even in the early 1980's. Research and development can help balance our energy budget in the 1980's and the 1990's, but there is an urgent need for action programs to use the coal as coal, to go for secondary and tertiary recovery, and to give people cars and homes and switch to industrial processes that are much more efficient.

BETTER EFFICIENCY OUT OF ENERGY

I was traveling to Japan about 3 weeks ago and the man sitting next to me was head of a delegation from the Portland Cement Association. I asked him why he was going to Japan. He said, I am going over there to look at the Japanese cement plants. They use a dry process that produces cement with half the energy per ton as American plants and it is just as economic so we are going over there to find out about these plants and see if we can convert. I think it is a false notion to think that American industry uses energy as efficiently as it might. Most industrial processes have been as wasteful in the use of energy as the average housewife. And I think by taxes and redesigning the rates for energy so that the price is higher, we can move industry to become much more efficient and grow economically and productively without the same massive rate of growth in the consumption of energy.

THE END OF AN ERA

The joy ride is over, Mr. Chairman. I think this Nation is going to have to face the fact that we are not in for a short-term emergency. This is not going to go away in 2 or 3 months or even a year or two. We have reached the end of an era of abundance in energy and it is time that we switched to a policy of conservation. I think the tax laws have to be a part of it, and I think this energy research and development agency has to have a strong utilization arm to it, as well as the supply side. There is a whole lot that can be done in research and development so that we can build houses and have cars and industrial processes in the 1980's that will enable us to grow economically without gobbling up so much of the world's resources.

Senator RIBICOFF. Senator Percy.

GOAL OF COMPLETE REORGANIZATION

Senator PERCY. Mr. Freeman, I think your testimony is exceptionally helpful. I was particularly pleased to see on the bottom of page 2 that you indicated your concern, which I, as a manufacturer had, about separating research from operations. It is just impossible to conceive that ERDA can operate as well as if research was intermeshed at some point with the more operational and broad-based functions. So is it your feeling that though this is an important interim step, we should never distract ourselves from the goal of achieving a full reorganization into a Department of Energy and Natural Resources? Do you support that concept?

Mr. FREEMAN. I certainly do. I worked with Lee DuBridge when he was science adviser very early in the Nixon administration, having stayed over from the Johnson administration. There was a proposal for a Department of Science. We opposed that. Research and development cannot be isolated from the real problems in the energy field. It has to be integrated with them. Research and development has to be performed to solve problems. While I favor this bill and believe that right now, we need to pull the research together and put someone in charge of it, to let it go its separate way could be a long-term disaster. This agency has to be integrated with the problems that we face and be a problem-solving agency, responsive to the policymakers, responsive to environmental bottlenecks as they occur, and responsive

to whatever problems we face in the energy field. This is a thought I leave with the committee, not suggesting that we hold up on taking this step, but realizing it is but a beginning of a complete reorganization.

As I wrote this testimony, we were greeted with still another agency proposal from the administration, which I gather we are going to be testifying about tomorrow and Thursday. It is almost as though we are engaged in a game of musical chairs. While I believe in supporting whatever needs to be done, at present, we should not look at this era as setting up a whole new bureaucracy that is not connected with itself.

A REAL PROBLEM—PICKING AN ADMINISTRATOR

Senator PERCY. At the bottom of page 3, you suggest that the agency have a new Administrator, not one just taken from the other fields, which might cause him to be oriented too directly in the direction of one particular source of energy. Is it within the charter of the Ford Foundation as a tax-exempt and nonlobbying institution, to permit you to make suggestions to the executive branch of Government? Could you offer them proposed names that might not occur to the executive branch for the type of person—you come in contact with so many people—that might not be available to the White House personnel people—I will call them "headhunters."

Mr. FREEMAN. Mr. Chairman, as I stated at the beginning of my testimony, I am appearing here personally, not on behalf of the Ford Foundation or the project. I was in the White House Office of Science and Technology.

Senator PERCY. Yes.

Mr. FREEMAN. We are prepared to be responsive to the Congress with respect to any specific request. In all candor, I do not have any specific names in mind. I was addressing myself in this testimony to what I feel is a real problem that many people have mentioned, a fear that we will just be giving the Atomic Energy Commission another name and the fear that this will not really be a new agency. This was just a personal thought. But to the extent that we can be helpful to the executive branch or the Congress on a personal basis, we of course would be willing to do so.

Senator PERCY. Well, any suggestion as to an individual that you might suggest, I would be very happy to see that it is passed on. I hope that would not kill them at the White House.

On page 4, you mention the desirability of having a modification in the legislation in the direction of a new energy R. & D. plan for the agency.

IMPLEMENTING SUGGESTIONS

Do you happen to know whether work has been started in the Congressional Research Service, or by anyone in the Senate or the House, to implement some of the suggestions you have made here?

Mr. FREEMAN. Senator Percy, I testified on the House side last week and made a number of these same suggestions. I do not know what the bill coming out of the House Committee and committee reports will contain. I believe that many of these suggestions were received favorably by the committee.

Mr. WEINHOLD. When we mentioned the specific suggestion dealing with the annual report, Chairman Holifield indicated that they had

intended to include a section on an annual report, not as extensive as ours, but that it had somehow fallen through the crack. They were very sympathetic.

Senator PERCY. That is with reference to S. 1283, is it?

Mr. WEINHOLD. Yes.

Senator PERCY. Fine. We just want to coordinate our activities and not be guilty of duplication.

That is all the questions I have, Mr. Chairman, but I would like to make one additional comment. Several years ago, one of our former colleagues who is no longer in the Senate, attempted to put a death sentence on foundations. He said they ought to be legislated out of business and that we ought to do more of these things by government. I am constantly impressed with the tremendous quality of testimony that is being given to us by people who associate with foundations and who, unlike us, because of the charter of the foundation, have time to think long range about these problems. That is one thing I think we lack, the ability to take the time to think things through. Your contribution, I think, in this testimony is invaluable and I hope you will express that sense of appreciation to Mr. Bundy and others.

Mr. FREEMAN. Let the record show that I am blushing.

Senator RIBICOFF. Senator Chiles?

DEREGULATION OF NATURAL GAS

Senator CHILES. I wanted to get your comments in regard to what would be the help or hindrance of the deregulation of natural gas?

Mr. FREEMAN. Senator Chiles, perhaps I am not the most impartial witness on that subject. I was Assistant to the Chairman of the Federal Power Commission from 1961 to 1965, and it is my personal view that the Federal Power Commission has been getting a very bum rap in being blamed for the natural gas shortage. The natural gas industry grew from almost nothing to the sixth largest industry in the country under FPC regulation over the years, including regulation over well-helped prices from 1954. It had an enormous rate of growth. Apparently, the prices were adequate for natural gas production to be dedicated in interstate commerce for a 17- or 18-year period at enormous rates. There is today a shortage of natural gas in Louisiana and Texas, where there are no price controls, at least as serious as in interstate commerce. There is a shortage of oil where the Federal Government has been propping up the price over the last 15 years, at least as serious as natural gas. If you are looking for a villain on the natural gas side, I think you ought to look at the Secretary of the Interior as an office, not a person, where the Federal leasing program has been prodding at a snails pace over the years. It does not really make a difference what the price of natural gas is, Senator Chiles, if the Federal Government is not offering leases for sale. It is pretty hard for industry to develop the resource and bring it to market.

SHIFT IN DEMAND

There has also been a large shift in demand toward natural gas because it is such a clean fuel and the demand has exceeded the projections made in the sixties.

Having said all that, I believe if we look to the future, we could decontrol the price of new gas on non-Federal lands, mostly onshore, which would encourage independent producers to develop more of the resource. But I think if you analyze the question of the gas shortage, you may perhaps give the Federal Power Commission activities a chapter or two in the book, but the book is made up of a lot of other reasons.

There has been a tendency to oversimplify and to suggest that somehow, because the people of the United States got natural gas at a reasonable price and the Federal Power Commission saved consumers hundreds of millions of dollars over the years, that this has caused a gas shortage. It has not. I look back at my years with the Federal Power Commission as years of useful public service. I do not think we extinguished a single thousand cubic foot of gas underground. The gas that is out there in the OCS is still there. If we could develop a leasing program and the proper incentives and a program that would let smaller people come in, royalty bidding, perhaps concessions, other forms of leasing, and learn more about the resource, I think we could enlarge the supply of gas and oil in the years ahead.

INTRASTATE GAS USAGE

Senator CHILES. What about the argument that we are hearing now that some of the States that have natural gas that can use that gas within their State, intrastate, without regulation and therefore prohibiting its shipment and are in effect using it as an inducement to get business to come there and use it, and therefore, they are becoming like small Saudi Arabias and they are not going to share the resource. The argument that runs that if you deregulate it, that would then come into the process and make one of the most immediate changes in the level now of what we would have for consumption?

Mr. FREEMAN. Senator Chiles, we are still a Union and we have not gone back to the Articles of Confederacy. It is against the Constitution and contrary to the interstate commerce clause for a State to arbitrarily prohibit the export of natural gas interstate.

Senator CHILES. Well, by placing a tax on the export, by doing everything they can to effect that, are there not some States doing it? I do not know. I am just hearing some of the arguments and I have no persuasion on this right now. I am seeking enlightenment.

Mr. FREEMAN. Senator Chiles, if the gas has been discovered and has been dedicated in interstate commerce by the companies involved under the Federal Power Act there is no legal way that they can withdraw that gas and redirect it to intrastate commerce. While many people in Louisiana and Texas may be scratching their heads and wondering how could they have a gas shortage in their State and suggesting that, perhaps their policies in the past were not as self-protective as they could have been, it is not feasible legally or practically to withdraw gas that is already flowing.

Now, in terms of new gas supplies, obviously, there are no price controls intrastate and indeed, a very high percentage of the gas is consumed in Texas and Louisiana. I grew up in the Tennessee Valley and I think that if a region has a natural resource, it is economically in the cards for industry to be attracted to that region. And of course, the Texas Gulf Coast is living proof that the oil and gas resource of

Texas has been a basis for economic development of Texas and it should continue on the basis of economics. The gas is not going to be shipped to New York if someone will pay more for it in Texas.

THE PEOPLE OWN OCS, BUT DO NOT KNOW WHAT IS THERE

The answer to the problem is not a Balkanization of the United States, but the National Government putting a good deal more effort into learning what the people of the United States own in the Outer Continental Shelf and moving to programs that will not only protect the environment but also develop the resources on the basis of that knowledge.

The heart of the matter, Senator, is that of all the billions of dollars we talked about earlier receiving and that the Government has received from these sales of oil and gas, very, very little is spent in trying to find out what is out there, in learning the environmental problems, in moving to a leasing or concession program that would move faster. We are falling down on our job as a proprietor.

Senator CHILES. Do you think the proprietor of the Federal Government should continue now, under today's contingencies, to grant this on a finder's-keepers basis, or do you think that the Federal Government should consider contracting out the exploration themselves, proving the reserves themselves, and then going into a bid or sale arrangement? Or is there some other way of doing it?

NEW METHODS SOUGHT FOR FEDERAL PROPERTY DISPOSAL

Mr. FREEMAN. Well, without unduly prolonging my answer, I feel very strongly that the Federal Government needs to move to entirely different methods of disposing of the Federal property out there, methods more in keeping with the energy-environmental concerns the Nation now has. When I was with the Office of Science and Technology, I headed a study group 3 or 4 years ago and we recommended a royalty bidding which in effect would be profitsharing, would permit more companies to put more money in exploration and development rather than putting their money into bids. This recommendation was not accepted by the Interior Department, although the statute expressly provides for royalty bidding.

Senator CHILES. The statute does provide for it?

Mr. FREEMAN. It only provides for two types of bidding, cash bonus and royalty, and the Interior Department has never experimented with royalty bidding all these years.

EXPLORATION OF RESERVES BY INTERIOR

Senator CHILES. Would the statutes now allow Interior to contract for the exploration if they wanted to—not the sale, but to go out and prove the reserves or go out and determine what is there?

Mr. FREEMAN. I cannot answer that question definitively, Senator. I would suspect that it probably does, but I do not know for sure. But if additional legislation is needed to give them broader authority, I would assume that the Congress would be very receptive to considering such legislation. We are the only country on earth with oil resources that I know of that goes about it with this cash bonus method without any performance requirements.

Senator CHILES. That is my concern. If there is no performance requirement. Also, we know the companies have more information about what is in the ground and what is on the outer shelf right now than the government does. So they bid, almost knowing what is there, and we sell, not knowing what is there. It just seems to me—I do not want to see us nationalize the whole oil industry, but it seems to me that if we at least explored on a contract basis, if we at least knew when we were starting a sale what we were selling, we would be much better off than the way we are going now.

Mr. FREEMAN. Precisely.

Senator CHILES. That is all.

Senator RIBICOFF. Senator Nunn?

Senator NUNN. Mr. Freeman, I found your testimony very enlightening.

Senator PERCY. Senator Nunn, I wonder if it would be possible for me to ask three brief questions? I have an appointment upstairs.

Is your time schedule all right?

Senator NUNN. I am going to have to leave and preside in just a minute, but I will be glad to yield.

Senator PERCY. Thank you. I have just three quick questions. These could be answered for the record if any of them get into detail. The first does not.

I was not quite sure: Do you favor the organizational approach of S. 2744 or S. 1283? That is the management project which coordinates the existing energy agencies. S. 2744 is the administration bill that Senator Ribicoff is sponsoring, and S. 1283 is Senator Jackson's bill.

Mr. FREEMAN. Senator Percy, I do not know. I have not read the other bill. It is quite possible that the two are compatible with one another and that both should be passed. I realize I am ducking your question, but I honestly do not know.

Senator PERCY. If at any time, you come to a conclusion, we would certainly appreciate it before our vote.

FINANCING CONCEPT

Do you favor the energy trust fund or annual appropriations for R. & D.?

Mr. FREEMAN. A trust fund concept is very, very attractive. You might also consider a bank. If we get to financing production, commercial activities, I am afraid that the money for research and development could be drained off very, very quickly. In the REA program, where the Government loaned money, it proved very successful. I would favor loans for production plants and leaving the trust fund money for the research and development.

Perhaps you might consider a tax, a Btu tax on energy to raise additional money, because I am concerned, as I am sure Senator Ribicoff and you and everyone on the committee is concerned, with the point Senator Nunn made, that if we simply drain off the money, it will come from the health and welfare and education areas or mass transit or other things that might even be more helpful in solving the energy crisis. And actually, if we are going to spend more money, we need to bring more money into the Treasury.

Senator PERCY. Thank you very kindly.

Thank you, Senator Nunn.

Senator NUNN. I want to ask you about your view of the trust fund proposal. I believe that we have very little control over the budget now, we have so many trust funds. While this may perhaps be the most important subject we have now and I may very well be for a trust fund—I am just exploring this—we may end up with such a constituency that is just as hard to crack 10 years from now as the highway trust fund.

Mr. FREEMAN. I was impressed with Senator Percy's point that in terms of balancing the energy budget, it might be more important to develop a mass transit trust fund. The money for energy research and development I think will be coming out of the appropriation process. I would favor the trust fund for this effort, but I think you have to consider bringing new money into the Treasury.

You made the point, Senator, that I think is the heart of it, that in effect, we are just kidding ourselves if we take existing money and transfer it and feel that we have solved the budgetary problem.

TERMINATION DATE ON TRUST FUND

Senator NUNN. I think also if we do establish a trust fund, which I am openminded on, we ought to have a definite termination date and make the legislative history abundantly clear that we are not establishing the trust fund in perpetuity and that this money still belongs to the American people. Certain vested interests do not feel the American people have any interest in many existing trust funds.

Mr. FREEMAN. I am not against a trust fund. Yet people should understand that the Congress has not been negative on appropriating money for R. & D. The problem has been that we have not had programs presented to the Congress. We have not had an agency come up with a program. I think this legislation before you that would put somebody in charge of R. & D. to come up with programs and ask for sufficient money will go a long way. As I see the problem at the moment, it is not going to be solved by simply throwing money at it. We need to have people with competence and determination in charge of energy R. & D. with programs geared to the problems. There is a problem, it is going to take a lot more money, and I would think we should think in terms of some sort of Btu tax on fuels to bring more money into the Treasury so we are not robbing other programs that are just as vital to the Nation.

Senator NUNN. Mr. Chairman, I could ask a great many more questions, but I want to close with one more, because we do have a time problem, and this has been, I think, very excellent testimony.

SHORT TERM R. & D.

Do you have in writing anywhere a summary of the dialog—I know it is not in your written statement—that you were having a moment ago about the short term steps we should take? I found most intriguing your analysis that the R. & D. we are talking about today is going to help us in the eighties and nineties, but we are kidding ourselves if we think it is going to be the answer in the seventies, and what we have to do now, while we continue this R. & D. legislative effort, we have to be aware of the short term problems and take the steps necessary. Do you have any kind of presentation on these kinds of short term steps other than what has been put in the record?

Mr. FREEMAN. Yes, Senator, I could send you my testimony before the Finance Committee last week that mentioned several of these items and try to find some other material. I will send you what I have, sir.

Senator NUNN. Thank you very much.

Mr. Chairman, I have no further questions.

Senator RIBICOFF. Thank you very much.

SECONDARY AND TERTIARY RECOVERY

Just one final question. I am not sure it is in the record. How long would it take to develop the secondary and tertiary supply of oil from present sources of supply?

Mr. FREEMAN. Mr. Chairman, Mr. Weinhold can answer this question in more detail, since he is working on this particular problem in a very intimate way.

Mr. WEINHOLD. Secondary recovery is a technology we are using right now. It involves water flooding technology and is part of the business now. Secondary recovery, perhaps, can be extended and we can obtain more oil out of it.

Tertiary recovery is really in the development or demonstration stage. Very little oil has been produced by tertiary means. There are lots of good ideas but people have not made that big plunge to develop them. It is going to require several years—3 or 4 years, probably—to test a large number of processes. Then industry must move aggressively and commit them to large numbers of oil fields. So there will be a 4-, 5-, or 6-year delay before you get large quantities of tertiary oil.

Senator RIBICOFF. So when all is said and done, for the next 5 years, it is going to have to come out of conservation and the more economical use of our energy?

Mr. WEINHOLD. And perhaps some additional secondary recovery.

Senator RIBICOFF. Secondary recovery. Because we are the most wasteful Nation in the world. My understanding is that just over half of the energy we produce as a Nation we waste.

Mr. FREEMAN. Yes, sir.

Senator RIBICOFF. Thank you very much, gentlemen.

Senator NUNN. Mr. Chairman, I have to preside and I must leave. I will be back this afternoon.

Senator RIBICOFF. Thank you very much for coming.

Mr. John Simpson.

You may proceed, sir.

TESTIMONY OF JOHN W. SIMPSON, PRESIDENT, POWER SYSTEMS CO., OF WESTINGHOUSE CORP.

Mr. SIMPSON. Good morning, Mr. Chairman. I am John W. Simpson, president, Power Systems Co., Westinghouse Electric Corp. I welcome this opportunity to appear and express my support of S. 2744 to establish a new Energy Research and Development Administration—ERDA—and a Nuclear Energy Commission—NEC.

In my career I have been associated with a significant number of major research and development programs and advancements of technology. Based on this experience, I am in favor of S. 2744; you

will assure the best combination of Government resources to help solve the extremely serious national energy problem.

I support the creation of ERDA since it places responsibility for energy research and development under a single agency rather than several. The selection and funding of research must of necessity take into consideration all options, costs, timing, and probability of success—not only as a technical achievement, but also as a viable contribution to the economy. When similar or complementary research and development projects are done in different organizations, objective judgment on the best course to follow becomes almost impossible; and objectivity is hard enough to obtain in any event.

It has been my experience that in research and development projects where industry and the Federal Government work together, the best results are obtained only when the government scientists and engineers and their industrial counterparts are both highly capable and experienced. ERDA is being formed from Government agencies who have the required scientific capability, particularly the broad base of knowledge of the Atomic Energy Commission's staff and its laboratories.

ERDA will have the capability and should develop every energy source which makes us less reliant upon imports and contributes to meeting our national needs.

When the research and development programs of ERDA mature, and even though they may be technically successful, they will have to compete in the economic marketplace. Perhaps only one or at most very few will make the grade. Despite this fact, it is necessary to go forward with research and development on all suitable energy projects: It is a small price to pay for being able to make a wise selection in planning our energy supply mix for the long term future.

A SEPARATE NUCLEAR ENERGY COMMISSION

Since nuclear energy will play the important role in our economy I describe later, the licensing and regulation of nuclear plants will be important. The creation of a separate NEC is a step in the right direction. In my opinion, having both regulatory and promotional activities in one, the Atomic Energy Commission still protected the public interest. However, I believe the creation of a separate NEC will remove this point of controversy.

A properly organized NEC with an adequate staff and an effective safety R. & D. program should result in assured public safety, nuclear plants being licensed with less delay, fewer court challenges, and savings to the consumer of electricity.

AN ELECTRIC ECONOMY BASED ON NUCLEAR ENERGY AND COAL

Despite the best efforts of ERDA, new energy sources cannot be of much help in our becoming self-reliant by 1985. What can we do? The United States should start converting now to an electric economy based upon nuclear energy and coal.

By 1985, natural gas will be used at about the same rate it is now, but will be a smaller percent of the amount of total resources consumed because more energy will be needed.

Second, there is simply not enough oil in the United States—including Alaska and the Continental Shelf—of proven plus potential

reserves to furnish the energy that will be needed if the demand for oil continues to increase at present rates. If we are to cut the demand and stretch the reserves, we must use petroleum only for those uses for which we cannot find a substitute. Today, this includes automobiles and some electric power generation. For the long term this includes lubrication, petrochemical feedstocks, jet aircraft fuel, and fuel for gas turbine electric powerplants.

This leaves coal and nuclear fuel as our only abundant supplies, and they are best used in an electric economy. The amount of electricity for present uses will increase because of demand. But electricity can also be used in place of petroleum for such things as home heating, industrial and commercial space heating, industrial process heating, mass transportation, and electric cars. In many of these it is clearly a more efficient use of energy than using the oil or gas directly.

Currently, coal is being mined as fast as the industry is capable. It is estimated by 1985 that 400,000 megawatts of our electric generating requirement of 1,200,000 megawatts and 40 percent of our industrial process needs could be met by coal. This will require almost three times as much as was mined in 1972. After allowing for usage of oil, gas, and hydro to generate 300,000 megawatts, there is a gap of 500,000 megawatts which must be filled by nuclear generating plants. If oil were used to make up the 500,000 megawatts difference, 210 billion barrels of oil would be needed to fuel these plants over their economic life. That is more than the total United States proved and potential oil reserves.

The industrial base exists to shift to an electric economy, and I believe it can be done if it becomes a matter of top national priority and national will. I must point out that our industrial might depends on energy, and it is being weakened today. Dependence on Mid-East oil is not a desirable form of international life for the United States. We are not dependent on Mid-East oil today for survival—only for comfort and life as usual; but if we do not take steps today to move to a nuclear electric economy and the oil starts flowing from the Middle East again and we become dependent on it, we face danger.

SELF-SUFFICIENCY BY 1985

I believe my approach has the possibility of giving us self-sufficiency by 1985. I have read countless reports on the energy crisis, listened to many speeches, talked to many government and industry officials; and so far no one has a better way of doing it.

I submit that the program I am suggesting should be studied for feasibility immediately as a matter of highest national priority. I sent a letter on Tuesday to the President of the United States which carries these same thoughts.

Mr. Chairman, I commend you and your subcommittee for your timely attention to a problem which will take decades to solve. In the exchange and evaluation of ideas in forums such as yours, the right approaches will be found. I thank you.

Senator Ribicoff. Thank you.

Mr. Simpson. I would like, if possible, sir, to submit for the record the statement that I gave last week to the House Government Operations Committee on behalf of the Executive Committee of the Atomic Industrial Forum of which I am the vice chairman, and to append to

that a letter from Mr. William R. Gould, the chairman of the Atomic Industrial Forum.

Senator RIBICOFF. Without objection, so ordered.

[The above-referred-to documents follow:]

ATOMIC INDUSTRIAL FORUM, INC.
New York, N.Y., December 4, 1973.

Hon. ABRAHAM RIBICOFF,
Chairman, Subcommittee on Reorganization, Research, and International Organizations, Committee on Government Operations, Washington, D.C.

DEAR SENATOR RIBICOFF: The Executive Committee of the Atomic Industrial Forum is pleased to transmit for inclusion in the record of hearings on S. 2744 the attached statement by John W. Simpson on H.R. 11510, an identical bill now pending before the Legislation and Military Operations Subcommittee of the House Committee on Government Operations. The statement was presented by Mr. Simpson in his capacity as Vice Chairman of the Atomic Industrial Forum.

The Executive Committee strongly endorses the establishment of the Energy Research and Development Administration and the Nuclear Energy Commission, and urges your committee to take prompt action on S. 2744. We also believe, however, that in the case of the Federal licensing of nuclear power plants, reorganization will not in itself expedite the process to the extent necessary if nuclear power is to play a significant part in alleviating the energy crisis now facing the nation. Such reorganization must be accompanied by fundamental reforms in the licensing procedures. Mr. Simpson's testimony contains a number of recommendations in this regard; also, we have recently requested the Joint Committee on Atomic Energy to schedule hearings on licensing at the earliest possible date. We urge this committee to encourage the holding of such hearings as a parallel to the reorganization initiative you are taking.

Since Mr. Simpson's testimony was submitted on H.R. 11510, the Administration has announced the creation of a new Federal Energy Administration in the Executive Branch. We believe enactment of S. 2744 is consistent with this action and, therefore, there should not be a delay in this committee's deliberations on the bill. Nevertheless, if it becomes evident that other provisions of the bill may be delayed by this or any other action, we recommend that the Nuclear Energy Commission be established at the earliest possible time.

Sincerely,

WILLIAM R. GOULD.

STATEMENT OF JOHN W. SIMPSON, VICE CHAIRMAN, ATOMIC INDUSTRIAL FORUM, INC.

Mr. Chairman, and members of the Committee, I am pleased to be here today on behalf of the Executive Committee of the Atomic Industrial Forum, Inc. to discuss issues relevant to H.R. 11510, a bill introduced by the Chairman and others to establish a new Energy Research and Development Administration (ERDA) and a Nuclear Energy Commission (NEC).

The Atomic Industrial Forum is a not-for-profit membership corporation organized in the State of New York. Its members comprise nearly 600 corporate and institutional members in the United States as well as in some 25 other countries, all of which share a common interest in the development and application of atomic energy for peaceful purposes. Because of the diversity of its members, which include utilities (both public and investor-owned), manufacturing companies, engineer-constructors, mining and milling companies, universities, labor unions, professional firms, financial institutions, government organizations, and other profit and nonprofit entities, the Forum, as a matter of policy, does not take positions on matters pending before the Congress. However, when possible, we do make an effort to identify relevant technical, legal and policy considerations and to provide a mechansim for determining and articulating the views of our various members.

H.R. 11510 contains a declaration that it is in the public interest that the licensing and regulatory functions of the Atomic Energy Commission should be separated from its other functions, which would be transferred to ERDA. These activities would be reconstituted in a Nuclear Energy Commission.

As AEC Director of Regulation, L. Manning Muntzing, stated before this Committee when testifying on H.R. 9090 on July 31, there has been almost uniform agreement among those who have studied the problem that a separate

regulatory commission for nuclear matters should be established at an appropriate time. We agree with this consensus and believe that the time for separating the Commission's regulatory and promotional functions is now at hand. Our conclusion in no way constitutes a reproof of the AEC for the manner in which it has carried out either its regulatory or promotional functions. As the Chairman is well aware, during the early days of nuclear energy, the Commission was essentially the exclusive source of expertise for nuclear technology. It was quite logical and indeed necessary that as the technology was developed, the Commission should perform the research and establish the regulatory provisions required to ensure its safety. The record has been an exemplary one.

As the nuclear industry has grown, the Commission has adjusted its internal organization to separate its regulatory and promotional functions and as Mr. Muntzing pointed out, they are now virtually the responsibilities of two separate agencies brought together at the level of the Commissioners.

Nevertheless, the Commission has been subjected to criticism for an organizational structure that is said to lend itself to a conflict of interest in nuclear plant licensing cases. We believe that this criticism is unjustified and would not of itself warrant sufficient ground for separating the principal functions now under the jurisdiction of the AEC.

We are mindful that there is a need for balanced decision-making in developing the regulatory framework for licensing nuclear power facilities. There is a danger that a separate Nuclear Energy Commission could become unduly conservative in establishing safety standards and require measures that are neither necessary nor desirable and that could impede the development of nuclear power as a principal energy source for the country. Forum groups have been critical in certain instances in the past of what were considered to be overly conservative positions taken by the AEC's regulatory staff and we have had our share of complaints of what we have called "ratcheting" and the imposition of unnecessary and redundant safety features at each stage of the licensing and construction process. Separation of the licensing and promotional functions would tent to exacerbate this situation. We wish to emphasize, therefore, the necessity that a balanced approach to regulatory decision-making be taken within and by the NEC.

The relationship of the NEC to ERDA will be an extremely important one. It is important that the exchange of technical information between the two agencies be facilitated. It is essential that new developments in reactor safety that come to light through the regulatory process be transmitted to ERDA so as to incorporate the best safety features into advanced reactor designs. While ERDA will bear the primary nuclear safety, research, and development responsibilities for advanced systems, as a minimum NEC should have a sufficient research and development capability under its own control so as to be able to discharge its responsibilities for independently validating safety margins. There will undoubtedly be a need for continuous interaction among ERDA, NEC, private industry, and other government agencies in the continuous on-going evaluation of safety mechanisms being built into plants today and designed for those to be built in the future.

With respect to consolidating all energy research and development into a single administration and the prospect of significantly increasing the commitment to federal research and development over present levels, we wish to underscore the importance we ascribe to maintaining a strong commitment to nuclear energy even while up-grading federal research and development support for other energy technologies. We agree that increased research and development is needed for non-nuclear energy applications, but it should not be achieved at the expense of a reduction in nuclear energy research and development.

While we agree that the time is ripe to separate the Commission's regulatory functions, its impact on the on-going licensing program must be carefully considered, particularly with respect to potential transitional problems, including the provision of adequate manpower. This is particularly urgent in view of the current energy crisis facing our nation. Moreover, as the Committee knows, the President, recognizing the substantial contribution which nuclear power can play in closing the gap between supply and demand, recently called on the AEC to reduce the long lead times for the licensing of nuclear power plants. This will not be accomplished through mere reorganization, but the creation of the new NEC provides an appropriate occasion for instituting licensing reforms which would help to simplify licensing procedures and reduce delays in bringing these badly needed facilities on the line.

The NEC must be provided adequate staffing and technical assistance in order to reduce the long license application processing times that the industry has been

and continues to be experiencing. In this connection we have noted the statements of both Mr. Muntzing and Commissioner Doub that recent cuts in the regulatory staff budget will mean that their announced plans for reducing the license processing time cannot be implemented. We believe this to be extremely unfortunate. We are very much concerned that current efforts to implement faster reviews of standardized plants and systems will have to be curtailed due to inadequate manpower at the staff level.

We must also voice our concern over the possibility that the salutary move to identify generic issues and then hold rulemaking hearings on those issues separately from individual licensing hearings might also have to be curtailed by lack of manpower. Standardized plant reviews and hearings on generic issues are both essential to shortening licensing time. We strongly urge, therefore, that during the transition to the NEC the new commission be given all the authority and all the support it requires to attract and retain the technical manpower necessary to carry out and to accelerate the existing initiatives for speeding up the licensing process.

As the Chairman knows, the time required to obtain a license to construct or operate a nuclear power plant has increased drastically over the last several years with current estimates running 9 to 10 years. If this time is to be substantially reduced as the President has requested, substantial changes will need to be made in the licensing procedures. Important among these are restriction of the hearing at the operating license stage as proposed by the AEC last year; elimination of mandatory review by the Advisory Committee on Reactor Safety of each application as proposed by the AEC several times in the past; and modification of the section 105(c) prelicensing antitrust review to permit issuance of a construction permit or operating license subject to completion of the antitrust review.

Consideration also needs to be given to the establishment of siting procedures which will provide for final approval of sites at an early stage and which will coordinate and consolidate the interests of Federal, state and local agencies. Several bills are now pending before the Congress which seek to accomplish these objectives.

In addition, at the agency level, steps need to be taken to use existing authority to streamline staff review and simplify hearing and appeal procedures. Commissioner Doub recently indicated that he favored reestablishment of procedures which, in certain circumstances, would permit construction to begin in advance of issuance of the construction permit. This would be a step in the right direction. Consideration should also be given to eliminating the Atomic Safety and Licensing Appeal Board in favor of appeal directly to the Commission. The appeal board was established by the Commission two years ago in an effort to insulate the Commissioners from potential charges of conflict of interest resulting from their dual responsibilities of regulating and promoting. Since NEC will only have the licensing function, it is appropriate to put the Commission back into the decision-making process. The licensing of nuclear power plants involves important matters of public policy as well as technical considerations and the final licensing decision should be made by officials who have been appointed to administer the nuclear power program and who are sensitive to the broad public policy considerations which are involved.

While we believe it is important to consider licensing reforms such as those just mentioned as part of the reorganization of AEC, we are not suggesting that H.R. 11510 should be revised to cover them. Accordingly, these are clearly matters which require the immediate attention of the Congress, the Commission and the industry. Accordingly, the Chairman of the Forum, on behalf of its entire Board of Directors, recently requested the Joint Committee on Atomic Energy to schedule hearings at the earliest possible date to review the whole licensing process, including new measures as well as the current process. We believe a record of testimony from expert industry and government witnesses would help to pinpoint licensing pitfalls and thereby move rapidly toward meeting the President's goal. We would urge this Committee to encourage the holding of such hearings as a parallel to the reorganization initiative you have taken.

We also are mindful of the President's charge to Commissioner Doub and his interagency study group to review the total regulatory structure for the energy industry in this country with a view to improving energy regulation so as to assure that our energy needs will be reasonably, responsibly, and expeditiously met. While we do not believe that separation of the Commission's regulatory function need be deferred until the completion of Commissioner Doub's review, it is essential that the direction and preliminary results of this study be kept in constant view so that its effect on the establishment of NEC can be promptly taken into account and so that the transition from the present system to what is

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hopefully an improved and more responsive system can be managed with the least disruption and delay.

H.R. 11510 is similar to H.R. 9090, the Administration-sponsored energy reorganization bill, insofar as it establishes ERDA and NEC. However, at least with respect to NEC, we believe H.R. 11510 embodies a preferable approach since it spells out more precisely the responsibilities of NEC in two important areas, namely, the provision of research services required to support its licensing and regulatory functions and the provision for NEC licensing of certain ERDA facilities. The research provisions should help to assure that the Commission will have at its disposal the technical support which it needs to independently assess the design and safety features of nuclear facilities. The provision for NEC licensing of certain ERDA-sponsored demonstration projects will help to assure the licensability of these facilities when they become technically and commercially viable, as well as facilitate the exchange of technical information between the agencies.

In conclusion, the Executive Committee of the Atomic Industrial Forum supports the objectives of H.R. 11510. We endorse the establishment of a Nuclear Energy Commission and believe that the separation of authority which will be accomplished in this manner will help the nuclear power industry provide a larger share of our nation's needed energy supplies more rapidly and so assist in alleviating the energy crisis we are now facing.

Senator RIBICOFF. We do appreciate your coming here and because of the time element, I wonder, Mr. Simpson, if I submitted a series of questions to you, would you be good enough to answer them for me in writing?

Mr. SIMPSON. Most certainly.

Senator RIBICOFF. We will submit them to you and if we could have the answers in a week—you will not find them complicated—I am sure you and the staff together can pull them together.

Mr. SIMPSON. Most certainly, Mr. Chairman.

[The material supplied for the record follows:]

Question No. 1. How much of its own money should private industry and the Federal Government invest in research in the next 10 years?

Answer. It is my opinion that the $20 Billion proposed by the Federal Government is approximately the correct amount for the Government to invest in the next ten years. Private industry should invest approximately $8 to $10 Billion during that period. I arrived at that figure by using the approximately $1 Billion that Westinghouse expects to spend, and believe that should represent about 25% of that required in the generation, transmission and distribution research by private industry. Inasmuch as that part of the total electrical equipment represents only 10% but is the part that requires the most research and development, I am assuming that the remainder of the industry should spend at approximately one-half the scale on which they spend for generation, transmission and distribution.

Question No. 2. What plans for energy research does Westinghouse have for the next 10 years?

Answer. Westinghouse expects to continue with the major effort on improvement in pressurized water reactors and continue its development in the liquid metal fast breeder reactor. We expect that the first demonstration plant will be completed and that we will be involved in building some of the first commercial fast breeder reactors within the next ten years. We will continue work on the adaptation of the NERVA nuclear rocket engine for terrestrial applications such as coal gasification and the powering of surface-effect vessels for the Navy and others. We will continue the development of higher-temperature and therefore higher-efficiency gas turbines and continue to improve the availability and efficiency of steam turbines and generators. We will also be continuing work on uranium enrichment, the ability to obtain uranium as a by-product from phosphates and other processes, and continue our efforts at improving the efficiency of uranium mining. We will have a major effort in developing master computer controls 'or complete generation, transmission and distribution systems which would serve for economic load dispatch, protection and load shedding of non-essential loads during energy shortages. We will also have major projects on ultra-high voltage transmission, both AC and DC, in the 1100 KV to 1500 KV range. We have already built and tested the largest superconducting cryogenic

generator in the world and expect to continue with that program as well as a development program on cryogenic transmission. In an attempt to alleviate the problems caused by the waste heat steam generating plants, we are continuing the development of a wet/dry cooling tower line of products. We will, of course, be working in many other areas of energy research and development during this period.

Question No. 3. How much will it spend on energy R&D during this period?

Answer. In excess of $1 Billion.

Question No. 4. What could ERDA do to help conserve the consumption of electrical energy?

Answer. It could do research on many potentially effective ways of saving energy, such as improving insulation for buildings, for instance. It also can develop the expertise for evaluating the overall effect of many suggested measures for energy conservation and thereby advise the government and industry as to which are practical.

Question No. 5. Do you foresee any problems in assuring that the new knowledge developed by ERDA is put to immediate and effective use by private industry?

Answer. Yes, I believe that that will be one of the key problems. A positive method should be delineated, in writing, prior to starting a development program as to how the information will be transmitted to private industry so that it can be used effectively. The ability of a prospective contractor to assure that the knowledge developed will have widespread use should be an important cirteria.

Question No. 6. Should greater emphasis be placed in S. 2744 on demonstration projects or even Government support of full-scale commercial operations exploiting new technology?

Answer. I believe that ERDA should have the right to support demonstration plants exploiting new technology. Almost by definition, if the technology is sufficiently advanced to go to full-scale commercial operations, it should require little or no subsidy.

Question No. 7. Why do you say that new energy sources cannot be of much help in our becoming self-sufficient by 1985?

Answer. It is our estmiate and that of the Department of the Interior that the energy use in the United States in 1985 will be approximately 120 Quadrillion BTU per year. When one considers the magnitude of that amount of energy, it becomes apparent that—if anything is to be of much help, say 20% of that amount in 1985—it would require a proven technology with an industrial base for the manufacture, installation and construction of the plants already in being. If one follows the history of all major development projects, no one has ever come within an order of magnitude of reaching this size within a period of twelve years.

While some may consider that nuclear powe. as represented by the light water reactors is still a new energy source, and developmental, I consider that it is a mature industry at this time. The first attempt to build a nuclear power plant was started in 1946. The first demonstration plant of a commercial size was not finished until slightly more than ten years later, and it was ten years after that in 1966 before a significant number of plants were bought. Today, twenty-seven years later, we have a relatively small percentage of the total enregy used in the U.S. being provided by nuclear energy.

However, currently there are 200 million kilowatts of nuclear plants in operation, under construction or on order, and I believe it is possible that 500 million kilowatts could be in operation by 1985 and this would be of significant help.

Question No. 8. Prior witnesses at these hearings have suggested that one way to relieve the energy crunch in the next 10 or 15 years would be for the Government to provide the necessary incentives for the construction of plants to extract gas from coal and oil from shale. Would this be preferable to putting all our hopes on increased construction of nuclear power plants?

Answer. I believe that necessary incentives, including research and development and demonstration plants, should be provided to develop the processes and exploit the possibility of extracting gas from coal and oil from shale. I believe that gas can be extracted from coal, and the first commercial plants could be in operation in the early 1980s. The energy produced in this manner will be quite expensive compared with that produced by nuclear plants but will be required for gas turbines and combined cycle peaking plants which are used such a small fraction of the year that the cost of energy is not so important as the capital cost. This gas, even at the higher price, will have other uses where it will be economically competitive. I feel less hopeful that the oil can be extracted from shale in a reasonable

time and at a reasonable cost. However, this source is so important that the development should continue with the hope that success can be achieved.

I do not advocate putting all our hopes on increased construction of nuclear power plants, and do advocate a large increase in the number of coal-burning electric generating plants. However, nuclear is the only one of the newer technologies to have been demonstrated in such magnitude, and therefore is the only one of which we can be certain.

Question No. 9. How many nuclear plants would have to be built by 1985 to give us self-sufficiency?

Answer. It is my opinion that, together with conservation measures, 1,200,000 MW of electric generation by 1985 could give us essential self-sufficiency. This would be broken down as follows:

500,000 MW of Nuclear
400,000 MW of Coal
300,000 MW of Oil. Gas and Hydro

Question No. 10. Will there be enough construction capability around in terms of trained personnel, equipment and financing to make this possible?

Answer. The industrial base exists today which is capable of being expanded in the time scale required in order to meet the final objectives. Starting today, the manufacturing plants for all the major components can be completed and turning out those components within four to five years in essentially any quantity required. If the need existed, the manufacturers could supply the necessary capital. Trained personnel for field construction and operation would be a problem, but I am convinced that there is sufficient time in which to train them if a proper program is initiated. There will be some shortages of engineers, particularly in the architect/engineer firms, unless there is a major shift to standardized plants. The necessary financing on the part of the buying utility can only be provided if they have proper rate relief from their respective utility commissions. However, inasmuch as this may be essential to the continued industrial and economic development of the United States, and considering the small percentage of our Gross National Product involved, it seems to me it is a small price to pay.

Question No. 11. What has caused the delay in constructing new nuclear power plants?

Answer. The delays have been many-fold. It is my opinion, however, that a great part is directly attributable to licensing and regulation or stems indirectly from that source. It is extremely time-consuming to prepare the preliminary safety report, and this report then requires in excess of a year for review by the regulatory bodies. Even if a plant is a duplicate of a previously built plant, a complete review is required starting from scratch. In almost all of the plants started in the late 1960s, major changes were required to satisfy regulatory requirements after construction had started. This required stopping part or all of the construction, redesigning, procuring the equipment and backfitting it into the plant. In many cases, startup could not be initiated because of the lack of an operating license. However, when the license was finally received and startup attempted, if some minor technical bug was discovered, lateness was blamed on the technical problem which was not really the root cause. Frequently during the licensing process a new question is asked or a new difficulty develops which requires extensive analytical work, and perhaps R&D and design, before the regulatory body can be assured that everything is satisfactory. This frequently takes a considerable amount of time and may well lead to physical changes in a partially constructed plant.

There have undoubtedly been some delays in delivery of equipment to sites, but these have been relatively minor and, in most instances, major pieces of equipment have been at the site for many months awaiting installation.

Also, of course, there have been some instances of equipment not operating properly and having to be corrected or replaced. These have been on the whole relatively minor.

There have been a number of cases of improper documentation of quality control procedures or improper field construction work, and these have caused some delays.

There has been a very marked reduction in labor productivity over the past six or seven years. It should be noted that essentially identical plants sometimes take as many as twice the number of manhours at one site as at the other. This obviously extends the construction time. With the experience we now have, I believe it is possible to substantially reduce the time required to construct future plants, particularly with standardized plants and essentially mass-produced offshore nuclear power plants.

Question No. 12. How much can NEC do in eliminating these delays?

Answer. We have proposed to the AEC a number of things that can be done by the regulatory to eliminate delays. I am attaching a copy of a letter of December 4, 1973 to Chairman Ray outlining these.

Question No. 13. How much could ERDA do in eliminating these delays?

Answer. I do not believe that ERDA can play a major part in this area in the near future. If they do do safety research, they may be able to simplify the designs and add increased assurance of safety and this would certainly be helpful.

Question No. 14. Why do you say that the proposed reorganization of the AEC into NEC will result in nuclear plants being licensed with "less delay, fewer court challenges, and savings to the consumer of electricity?"

Answer. I say this because part of the lack of confidence in the AEC regulatory bodies stems from the fact that they have a dual responsibility that is both promotion and regulation. With a newly constituted NEC, with the entire organization including the Commissioners being responsible only for safety, I believe they will have increased credibility and there will be more acceptance by those who have been protesting nuclear plants that they have been properly studied and are safe. This certainly reduces the hearing times, would reduce the number of court challenges and, by saving construction time, would provide the power earlier and at less cost to the consumer.

Question No. 15. Would increasing the speed with which nuclear power plants were built endanger the health and safety of our citizens?

Answer. The answer to this is an emphatic "No." We have proposed no changes in any phase of the design, regulation or construction that would in any way endanger safety; rather, it is our opinion that the things we have proposed would in fact enhance it.

WESTINGHOUSE ELECTRIC CORPORATION,
POWER SYSTEMS COMPANY,
Pittsburgh, Pa., December 4, 1973.

Subject: President Nixon's Six-Year Target.

Hon. DIXY LEE RAY,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR DR. RAY: In a November 7, 1973 speech, President Nixon challenged the Atomic Energy Commission and the nuclear industry to reduce the time required to put nuclear power plants on line from ten years to six years.

A cycle of six years or less has been achieved in the United States in the past, is the practice abroad today, and again can be made the practice here in the immediate future. The steps that have to be taken are simple and possible. In this letter we have summarized our thoughts on what can be done in the licensing arena. Further studies have to be carried out before concrete ideas can be formalized on means to expedite construction, assure material and manpower availability and raise the necessary funds. When these studies are completed, they will be the subject of a later letter.

The key strategy to achieve a six-year cycle is to replace the current series process, i.e., licensing followed by construction, with a process in which both licensing and construction are in parallel. With about 200 nuclear power plants in the United States either in operation, in construction or under design the nuclear community has the experience to implement a parallel process which maintains the high standards of safety currently practiced, recognizes the importance of preserving environmental values, and, at the same time, allows early delivery of nuclear energy to ease the energy shortage.

The attached Figure 1 depicts the present licensing-construction situation. Before an application can be reviewed, the utility must select a site, choose its suppliers and prepare the PSAR—a process which can take up to 24 months. A construction permit from the AEC then is required prior to beginning site preparation and construction. An average construction permit application review and public hearing takes about 30 months, and no site work is allowed until this review is complete. Construction takes about six years after the permit is granted. Thus, the total time required to put a plant on line today can approach 10 years.

We believe that dramatic improvement in lead time could be achieved by paralleling the licensing-construction process. Figure 2 shows the near-term benefit to be gained.

The single most important step for the near term is granting an exemption for site preparation and preliminaty construction. To obtain such an exemption, we believe it is necessary first to have an Environmental Report prepared and a

mini-NEPA review conducted. (Of course, unless this review indicates the benefits from proceeding with preliminary work outweigh the costs, the exemption should not be granted.)

An adequate Environmental Report can be prepared in six months for a new site and in three months for an existing site as long as a plant of proven design is committed. The Environmental Report should contain a cost/benefit analysis showing that the benefits of early power generation, availability of site characteristics during the Staff review, etc. more than offset the risk, to the utility, of restoration costs and the harm to the environment if the site is found not suitable for a nuclear power plant. The cost/benefit analysis would, of course, be even more positive if the utility can demonstrate that its power demands require building a fossil plant at the same site if the site is unsuitable for a nuclear installation. Once the Environmental Report is filed, the Commission can conduct the NEPA review in two stages. The first stage, referred to above, as a mini-NEPA review, would concentrate on the cost/benefit analysis of the site preparation and preliminary construction exemption. We believe that this stage could be completed in 3 months. This period would cover the staff review, the preparation of the staff opinion, the publishing of notice in the Federal Register, and the evaluation of comments received in response to such notice. Granting of an exemption after this mini-NEPA review could save as many as 33 months. The second stage of the NEPA review process would be the detailed review as conducted today.

In parallel with the detailed NEPA review, the safety review of the plant would be performed. In this regard, elimination of repetitive reviews is needed. Designs previously reviewed by the Commission and designs that were part of an application which has received a recent Construction Permit should not undergo another detailed review by the Regulatory Staff. The Westinghouse 3425 MWt Nuclear Steam Supply System is an example of a design already reviewed by the Regulatory Staff. A reference document, RESAR–3, describing this NSSS, was filed in June 1972, and was subject to detailed generic review by the Regulatory Staff in conjunction with the Catawba application (ACRS letter issued on November 13, 1973). Material submitted to answer Regulatory Staff questions on RESAR–3 are incorporated in a new all-inclusive document, RESAR–3 Consolidated Version, filed with the Regulatory Staff on December 3, 1973. This document, which is used or will be used by more than 30 additional nuclear power plants should receive an "as-low-as-practicable" number of additional questions.

The struggle toward a more orderly licensing and construction process would be significantly eased if equipment important to safety could be procured with timely assurance of fabrication code applicability. Regulations today require equipment to be procured based upon fabrication code requirements calculated by subtracting time spans from the Construction Permit date. However, major equipment has to be ordered well in advance of the issuance of a Construction Permit, and fabrication code requirements cannot be definitively established when such orders are placed. We recommend that a fixed date is picked for application of fabrication codes, i.e., the date of application docketing.

With respect to the public hearing phase of the licensing process, we agree with the trend toward starting hearing activities as soon as an application is docketed. However, we believe more discipline is needed in the hearing process itself. The following are detailed suggestions to implement this discipline:

a. An ASLB should be appointed at the time the PSAR is docketed.

b. In the notice appointing the ASLB, the Commission should establish a completion date for the ASLB decision, which date would be subject to extension only for good cause.

c. The ASLB should be required to establish milestone schedules, again subject to change only for good cause. (See attached Table 1 for an example of an achievable hearing schedule.)

d. The principle of finality of decisions, as contained in Appendix M to 10 CFR 50 and in Section 2.503 of 10 CFR 2 should be adopted to prevent repetitive consideration of contentions covered in other licensing hearings.

e. Consideration should be given to the elimination of the Regulatory Staff as a party to the hearing. Regulatory Staff members might be made available to provide third party testimony and opinion upon request. This change would simplify the hearing process and would alleviate the present Regulatory Staff manpower shortage.

At the Operating License stage, we would like to offer the following two suggestions:

a. The Regulatory Staff review should focus on whether the plant as designed and built satisfies the commitments made at the Construction Permit stage. "Generic issues" which surface after the CP was granted should be backfitted only when the safety benefits of such backfitting outweigh the costs associated with such action. In this connection, the Commission must identify a clear mechanism to distinguish safety "musts" from safety "wants." Safety "wants" should not be backfitted and their adoption would be introduced only on future models in an orderly fashion.

b. The Operating License hearing should not wait for the ACRS letter or the Staff Safety Evaluation. We believe that the hearing process should be initiated soon after the FSAR is docketed and proceed in parallel with the Staff/ACRS review. The same type of discipline in terms of time constraints should be imposed here as were suggested for the CP phase.

We also believe that it would be most helpful if the Construction Permit were issued without waiting for the completion of the Anti-trust Review. The Anti-trust Review does not concern a matter of safety of environmental protection, and also is an operational and not a construction matter.

The discussion above is addressed to the near-term. In addition, we would like to briefly discuss the long-term licensing situation. Figure 3 shows the long-term solution which yields a cycle of 5.5 years without taking into consideration possible improvements in the construction phase. To make this a practical solution two prerequisites are needed:

1. Sites should be "qualified" independent of any commitments, from utilities, to build a nuclear station; and

2. The more significant components and systems of a nuclear plant, i.e., NSSS, containment, etc., should receive AEC approval independent of a utility's application.

Most of the near-term recommendations apply here. We would like to add the following:

a. The relationship between AEC, EPA and the various states should be better defined and simplified.

b. ACRS review of each plant should be made optional. With ACRS involvement on pre-selected sites and standard plant designs, mandatory ACRS review of each utility's application is not needed. In addition, the role of the ACRS, with the experience accumulated to date, should be reassessed.

c. The need for an Operating License hearing (provisional and/or final) should be reassessed. As a minimum, completion of the public hearing at the O.L. stage should not be a condition for full power operation.

In summary, a six year cycle is a practical goal. To meet this goal, changes to the licensing process can and should be made. The recommendations in this letter suggest some of those changes.

We would be happy to meet with you or members of your staff to discuss any of the above recommendations in detail.

Sincerely,

JOHN W. SIMPSON.

Figure 1. Current Situation

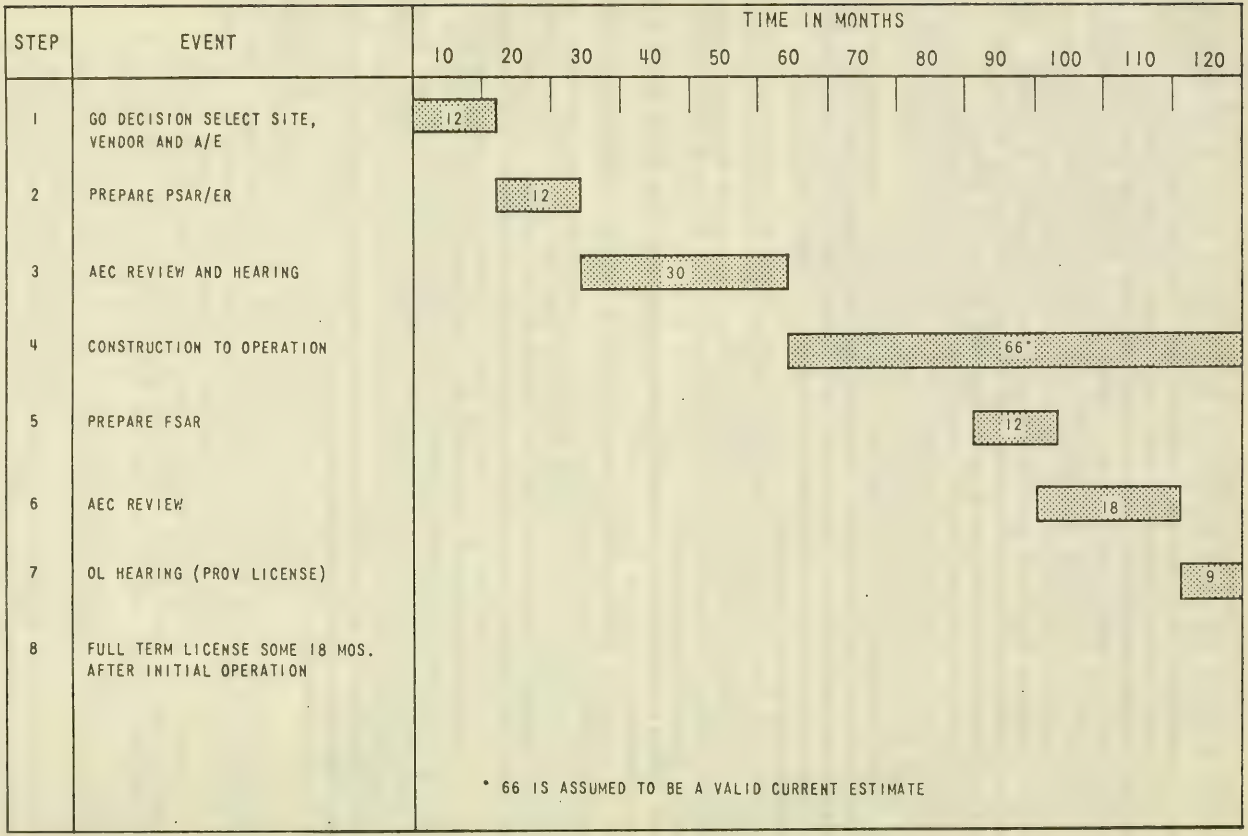
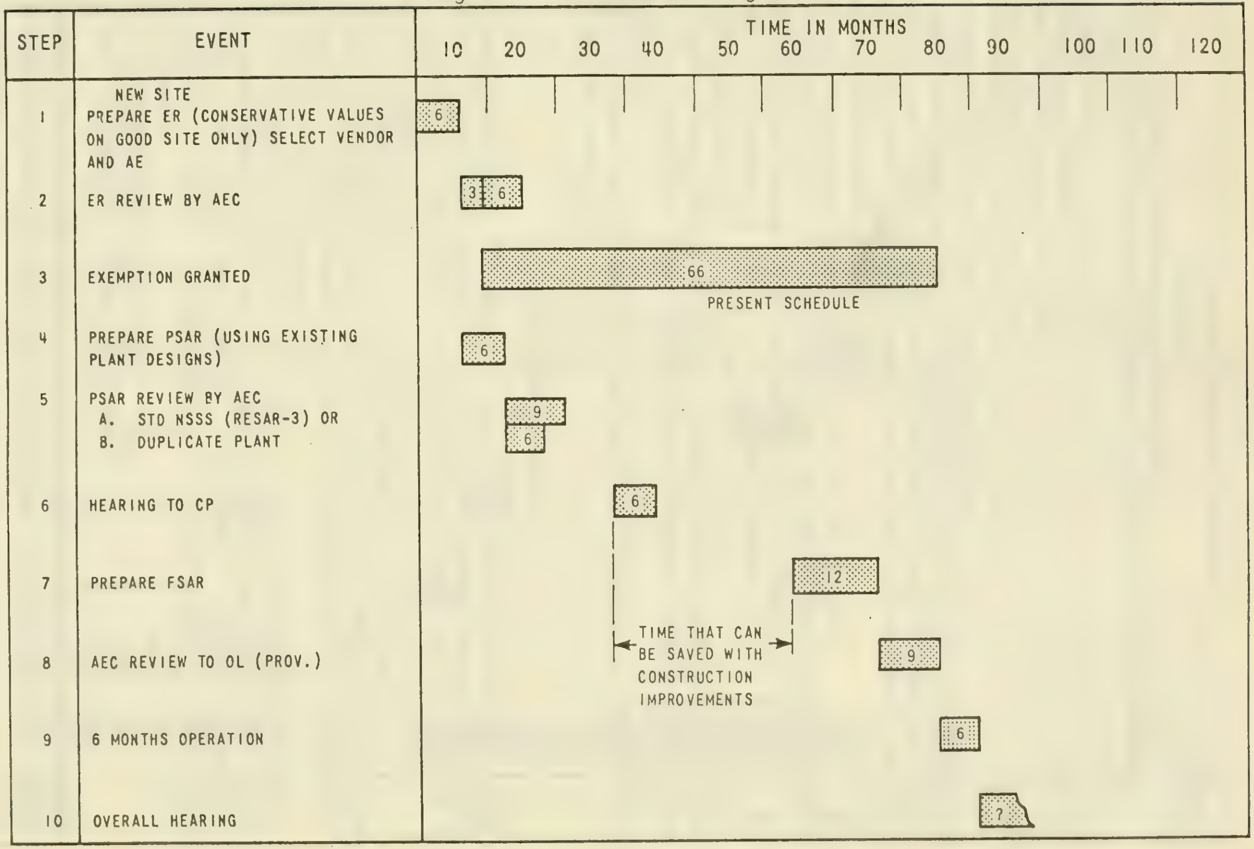
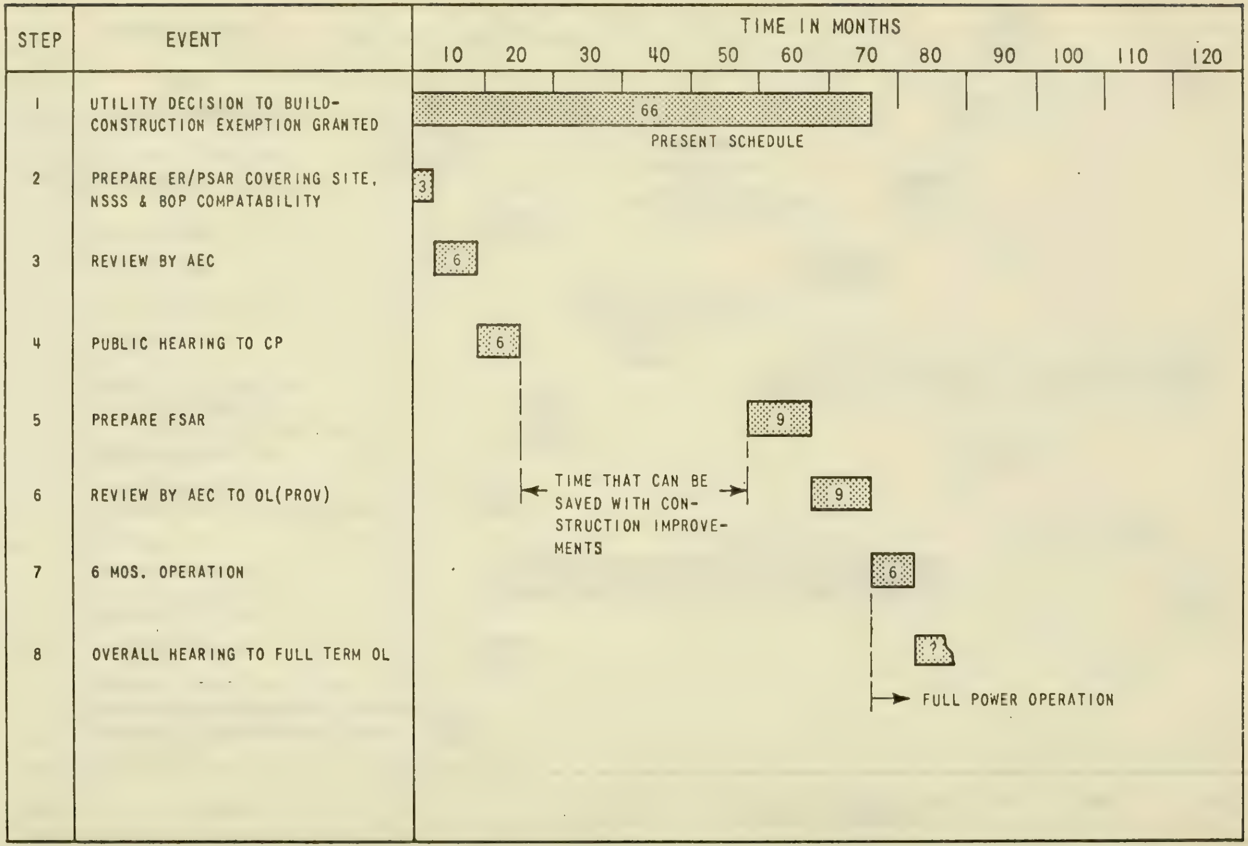


Figure 2. Transitional Licensing Solution



EXISTING SITE - SAME AS NEW EXCEPT EXEMPTION GRANTED AT 6 MOS. & OPER. AT 72 MOS.

Figure 3. Long Term Licensing Solution (>1976)



A TYPICAL HEARING SCHEDULE

Milestone	*Months from PSAR docket*
Appoint ASLB and establish completion schedule	1
Conduct the special prehearing conference (10 CFR 2.751a) and begin discovery	3
End discovery	7
Prehearing conferences	8
Begin hearing	9
Close hearing	11
Issue opinion	12

Senator RIBICOFF. Mr. Partridge, please.

Mr. Partridge, you play a very important role in this whole energy picture, and I am glad to have you here. I have to suspend soon and I am wondering if it would be an imposition upon you if I asked you to return at 2 o'clock?

Mr. PARTRIDGE. No sir; I would be very happy to.

Senator RIBICOFF. I think, as I say, you and your association have a basic role in this and I would just not like to slough you off.

Mr. PARTRIDGE. I will be very happy to return.

Senator RIBICOFF. Thank you very much.

Under those circumstances, the committee will stand in recess until 2 o'clock and the first witness this afternoon will be Mr. John Partridge.

[Whereupon, at 12 noon, the subcommittee recessed, to reconvene at 2 p.m., the same day.]

AFTERNOON SESSION

Senator RIBICOFF. Thank you very much, Mr. Partridge, for being with us. Would you proceed, sir. I was just curious, I see we have a lot of experts here, why does a public building have to be so warm on a day like this?

Mr. PARTRIDGE. I am very disappointed in the Senate, sir.

Senator RIBICOFF. I keep perspiring here, in the office, in the Senate dining room, I am just curious—when it is warm outside, is it not possible to shut off the system?

Mr. PARTRIDGE. It should be, with a modern building such as this.

Senator RIBICOFF. These are locked thermostats, I do not think you can operate them individually. You should be able to regulate the temperature to keep from perspiring. As you know there is a lot of fuel being wasted.

Mr. PARTRIDGE. That is right.

Senator RIBICOFF. Please proceed, sir.

TESTIMONY OF JOHN PARTRIDGE, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, COLUMBIA GAS SYSTEM, INC., WILMINGTON, DEL.

Mr. PARTRIDGE. I will just skim through my testimony.

I would just like to hit a couple of highlights of it. I would like to emphasize, for example, on page two.

Although natural gas is our prime interest, we support meaningful and appropriate efforts to provide our Nation with adequate supplies of all forms of energy. There is need and room for all, and our testimony today applies to all forms of energy.

I would like to interject, the natural gas industry operates over 1 million miles of pipeline, about a $50 billion investment. There cannot be any question that natural gas is the cleanest and most efficient form of energy. It must have a marked stake in the long-range program.

I will skip through the rest of that page, which just points out that there is an energy crisis. I do not think there is much question about that.

Then, we say that while there are many other actions that have to be promptly taken, the basic solution is the earliest possible implementation of a massive, all out, Federal energy research, development, and demonstration program. This has to be done on a high urgency basis, such as took place with the successful Manhattan and Apollo programs.

URGENCY FOR A MASSIVE R. & D. PROGRAM SET FORTH

The urgency and importance of this program mandates the following essential criteria:

First, it must be conducted by a fresh, new organization, independent of existing entities, priorities, and procedures, which pulls together the present fragmented Federal energy research efforts, and is charged with overall and specific accountability for meaningful results. It is essential that this program be subject to the least restraints possible, including those partisan and political—it must involve an independent effort by our best talent to do the job that must be done. This should involve inclusion in the new independent agency of all pertinent, existing Federal nonmilitary energy research activities, such as those in AEC, Department of Interior, NASA, and such as the National Science Foundation.

Second, it must be funded on a sustained basis—a trust fund which would provide a minimum of $2 billion per year for at least 10 years. This is essential so that needed funds can be utilized without any time lag and that long-range commitments can be readily made.

Third, it must have maximum flexibility to function at its management's discretion within broad policy guidelines. It must operate on a sound businesslike basis with sole authority to initiate projects of its own, by others, or jointly, and most important must be able to timely terminate or cut back projects if lack of progress so dictates.

Fourth, its management and responsibility should be vested in a Board of Governors consisting of key Government officials with primary responsibilities in areas related to energy and persons from the private sector with high qualifications and responsibilities in energy and relevant areas, appointed by the President with the advice and consent of the Senate. This board should be responsible only to the Congress.

We submit these criteria are requisite if the United States is to become self-sufficient in adequate energy as soon as possible.

S. 2744 AND S. 2694 COMPARISON

Although the objectives of S. 2744, the administration bill, are consistent with those required, its provisions meet only part of these essential criteria. However, a bill has been introduced in the Senate—S. 2694—which does meet them. It is attached as appendix A to my prepared statement.

A brief comparison of the major provisions of the two bills will demonstrate the differences.

The declaration of purpose is quite similar, except that S. 2744 provides for inclusion of military in the new administration. S. 2694 provides for military nuclear research under the Department of Defense. We do not have a strong feeling as to where military goes, we think it should be separated. Again, as I think someone testified this morning, that is a matter that can be looked into.

Both bills provide for the establishment of an independent executive agency. S. 2744 calls for its top management officers to be appointed by the President, by and with the advice and consent of the Senate, and they would be compensated in accordance with various levels of the executive schedule.

S. 2694 calls for management by a Board of Governors, consisting of eight key Government officials concerned with energy, and seven from the private sector having to do with energy and related matters. The private members would make a vital contribution of talent and experience at the policy level. Each would be "a person with high qualifications and responsibilities" from each of the coal, nuclear power, natural gas, petroleum and electric industries as well as from environmental and consumer organizations. All would serve without compensation. The Board would elect the top agency officers and set their compensation. The latter is most important because it is believed that current Government executive pay schedules would not attract the best talent available, which is needed for this effort.

Functions in the two bills are generally similar, but S. 2694 is more specific as to objectives and means of implementation, it gives more emphasis to demonstration projects, and its broader transfer provisions would enable ERDA to coordinate more comprehensively all Federal energy research and development programs.

Funding provisions are quite different. S. 2744 provides for the usual year-to-year authorization and appropriation procedure, which could severely retard proper progress of the program. S. 2694 calls for the establishment of a $2 billion per year trust fund.

One question was raised this morning by Senator Nunn, regarding the cutoff that is being encountered in cutting off the Highway Trust Fund. S. 2694 has the provision that this be reviewed at the end of 9 years to see if it should be continued, it is protected in that respect.

Those are the major differences, sir, between the two bills. We have attached an appendix which compares it in detail, but, in conclusion, we unequivocally believe that the S. 2694 approach is by far the right way to properly solve our Nation's most serious and critical energy problems.

S. 1283

We very much favor S. 2694, however, S. 1283 as reported out is a good bill, with two major areas which we have difficulty with. One is the funding it provides for the usual appropriation procedure wherein we were very glad to hear Senator Cook say this morning that he was going to propose an amendment that would try to substitute the trust fund project for the usual appropriation.

Our other major difficulty is, S. 1283 does not pull together the many fragmented Federal energy research efforts that are going on now. All they propose to do is to establish, I believe they call it a

"management project" which would supervise the many fragmented Federal research efforts.

We believe the only way to really quickly get on with the job that really has to be done is to pull together the pertinent research efforts under one authority—the urban approach if you will, sir. S. 2694, for example, mandates that all nonmilitary energy research be pulled from AEC, all energy research in the Department of Interior be put under the new Administration.

Then it gives the new research management the right to also incorporate any other energy efforts that they think are needed for this program to do the right job. I would strongly urge your consideration, Mr. Chairman, of an amendment, if S. 1283 is as imminent as it appears to be, with an amendment that would provide, in addition to the trust fund, to this pulling together of the fragmented energy research efforts.

Senator RIBICOFF. Thank you, sir.

Your prepared statement will be inserted in the record.

[The statement of John Partridge follows in full:]

STATEMENT OF JOHN PARTRIDGE, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER OF THE COLUMBIA GAS SYSTEM, INC., WILMINGTON, DEL.

Mr. Chairman, my name is John Partridge. I am Chairman of the Board and Chief Executive Officer of The Columbia Gas System, Inc., of Wilmington, Delaware, and past Chairman of the American Gas Association's ("A.G.A.") Research and Development Executive Committee. I appear here today on behalf of the American Gas Association and the Columbia Gas System.

The American Gas Association is a national industry association composed of some 300 distribution and transmission companies which deliver about 92 percent of the utility natural gas consumed by 150 million people in this nation. Natural gas provides about 31 percent of the nation's total energy requirements and 42 percent of its stationary energy needs. The Columbia Gas System directly at retail and indirectly at wholesale provides gas service to 4 million customers in an area with a population of some 18 million people in the seven states of Kentucky, Maryland, Ohio, Pennsylvania, New York, Virginia, and West Virginia, as well as the District of Columbia.

Although natural gas is our prime interest, we assure you that we support meaningful and appropriate efforts to provide our nation with adequate supplies of all forms of energy. There is need and room for all and our testimony today applies to all forms of energy.

The current critical energy situation should at long last convince Congress and the American public that the United States is in a deepening energy crisis with serious effects on our nation's welfare. However, we are concerned as to how well it is understood that at best—which we are far from having—no appreciable relief can be obtained for three to five years and longer.

Further, that even with the necessary measures to provide partial and short-term help, there remains a tremendous undertaking to make the United States self-sufficient in adequate energy supplies. Until this is achieved, we will be increasingly dependent upon foreign supplies with increasingly perilous uncertainties. We face, in fact, a deepening long-term problem that is certain to escalate with critical impact on our economy for *at least* a decade.

While there are many other actions that have to be promptly taken, the basic solution is the earliest possible implementation of a massive, all-out, Federal energy research, development and demonstration program. This has to be done on a high urgency basis—such as took place with the successful Manhattan and Apollo programs.

The urgency and importance of this program mandates the following essential criteria:

1. It must be conducted by a fresh, new organization, independent of existing entities, priorities and procedures, which pulls together the present fragmented Federal energy research efforts, and is charged with overall and specific accountability for meaningful results. It is essential that this program be subject to the least restraints possible, including those partisan and political—it must involve

an independent effort by our best talent to do the job that must be done. This should involve inclusion in the new independent agency of all pertinent, existing Federal non-military energy research activities, such as those in AEC, Department of Interior, NASA, and such as the National Science Foundation.

2. It must be funded on a sustained basis—a trust fund which would provide a minimum of $2 billion per year for at least 10 years. This is essential so that needed funds can be utilized without any time lag and that long-range commitments can be readily made.

3. It must have maximum flexibility to function at its management's discretion within broad policy guidelines. It must operate on a sound businesslike basis with sole authority to initiate projects of its own, by others, or jointly, and most important must be able to timely terminate or cut back projects if lack of progress so dictates.

4. Its management and responsibility should be vested in a Board of Governors consisting of key government officials with primary responsibilities in areas related to energy and persons from the private sector with high qualifications and responsibilities in energy and relevant areas, appointed by the President with the advice and consent of the Senate. This Board should be responsible only to the Congress.

We submit these criteria are requisite if the United States is to become self-sufficient in adequate energy as soon as possible.

Although the objectives of S. 2744, the Administration bill, are consistent with those required, its provisions meet only part of these essential criteria. However, a bill has been introduced in the Senate—S. 2694—which does meet them. It is attached as Appendix A.

A brief comparison of the major provisions of the two bills will demonstrate the differences.

The Declaration of Purpose is quite similar, except that S. 2744 provides for inclusion of military in the new Administration. S. 2694 provides for military nuclear research under the Department of Defense. Both provide for the licensing of regulatory functions of AEC to be vested in a Nuclear Energy Commission.

Both bills provide for the establishment of an independent executive agency. S. 2744 calls for its top management officers to be appointed by the President, by and with the advice and consent of the Senate, and they would be compensated in accordance with various levels of the Executive Schedule.

S. 2694 calls for management by a Board of Governors, consisting of eight key government officials concerned with energy,[1] and seven from the private sector having to do with energy and related matters. The government members would serve by reason of their office—the private members would be appointed by the President, by and with the consent of the Senate for specified staggered terms. The private members would make a vital contribution of talent and experience at the policy level. Each would be "a person with high qualifications and responsibilities" from each of the coal, nuclear power, natural gas, petroleum and electric industries as well as from environmental and consumer organizations. All would serve without compensation. The Board would elect the top agency officers and set their compensation. The latter is most important because it is believed that current Government Executive Pay Schedules would not attract the best talent available, which is needed for this effort.

Functions in the two bills are generally similar, but S. 2694 is more specific as to objectives and means of implementation, it gives more emphasis to demonstration projects, and its broader transfer provisions would enable ERDDA to coordinate more comprehensively all Federal energy research and development programs.

Thus, S. 2694, in addition to mandating certain transfers, provides for transfer of any Federal non-military research function, as in the agency's judgment is required.

Funding provisions are quite different. S. 2774 provides for the usual year-to-year authorization and appropriation procedure, which could severely retard proper progress of the program. S. 2694 calls for the establishment of a $2 billion per year trust fund. It would be funded by Federal receipts from all eligible energy sources, such as lease sales, and royalties without disrupting existing commitments. If such receipts do not total $2 billion in any fiscal year, the balance would be made up from general funds. If Federal energy leasing programs continue to

[1] (1) As Chairman of the Board, the official designated by the President as having primary responsibility for energy policy; (2) the Director of the National Science Foundation; (3) an Assistant Administrator of the National Aeronautics and Space Administration; (4) an Assistant Secretary of Defense; (5) a member of the Atomic Energy Commission; (6) a member of the Federal Power Commission; (7) a member of the Council on Environmental Quality; (8) the Administrator of ERDDA.

accelerate as they appear to be doing and as they must, it is doubtful that any help will be needed from general funds. This approach is equitable and appropriate because it earmarks funds generated by the sale of Federal energy development rights for the development of future energy sources.

We have covered above only the major differences between S. 2744 and S. 2694. The attached Appendix B sets forth a more detailed comparison, together with our position on the differences.

In conclusion, we unequivocally believe that the S. 2694 approach is by far the right way to properly solve our nation's most serious and critical energy problems. The real challenge not only on energy research, but on the entire energy problem, is whether we will continue to futilely attempt to meet it with traditional procedures, or whether we face reality and do what has to be done the right way.

APPENDIX A

S. 2694

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Energy Research, Development, and Demonstration Administration Act."

TITLE I

STATEMENT OF FINDINGS AND DECLARATION OF PURPOSE

SEC. 101. The Congress hereby finds—

(a) The Nation is currently suffering a critical shortage of environmentally acceptable forms of energy.

(b) A major reason for this energy shortage is our lack of an aggressive research, development, and demonstration (referred to hereinafter as "research and development," in accordance with Section 117) effort to develop a national capability for energy self-sufficiency by proper utilization of our large reserves of domestic fossil fuels, nuclear fuels, and geothermal energy, and the potentially unlimited reserves of solar power, nuclear, and other unconventional sources of energy.

(c) Many current uses of our limited basic energy resources, including the conversion of basic energy to an alternate form are highly inefficient.

(d) Current levels of funding by the Federal Government for energy research and development are inadequate and too fragmented to develop a program of the scope needed to insure efficient use of existing sources and to identify and develop the most technically, environmentally and economically feasible methods for utilizing energy from domestic resources.

(e) The capital requirements of a total energy research and development program of the magnitude needed are beyond the means of private sources.

(f) The Nation's critical energy problems can be timely solved only if a national commitment is made now to accord the highest priority, to dedicate the necessary financial resources, and to enlist our unequaled scientific and technological capabilities to meet the national energy needs, conserve vital resources, and protect the environment.

SEC. 102. (a) The general welfare, the common defense, and security urgently require and it is Congress' purpose here to undertake a national commitment to resolve the energy shortages and provide the means for achieving a national capability for energy self-sufficiency through socially and environmentally acceptable methods for producing, conserving, and utilizing all forms of energy.

(b) To effectuate that commitment it is Congress' purpose to consolidate and strengthen existing and initiate new Federal programs for energy research and development, in an Energy Research, Development, and Demonstration Administration, established hereinbelow and authorized and charged with exercising central responsibility for policy planning, coordination, support, and management of research and development programs, including commercial-sized demonstration plants, and respecting all forms of energy sources.

(c) The Congress further declares and finds that it is in the public interest that responsibility for all Federal energy research and development programs be transferred to the Energy Research, Development, and Demonstration Administration, and that this transfer be effected in an orderly manner assuring adequacy of technical and other resources necessary for the performance of such programs.

TITLE II

ESTABLISHMENT AND ORGANIZATION OF ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION ADMINISTRATION

SEC. 103. There is hereby established, as an independent establishment of the executive branch of the Government of the United States, the Energy Research, Development, and Demonstration Administration (hereinafter referred to as the "Administration" or "ERDDA").

BOARD OF GOVERNORS

SEC. 104. (a) The management and direction of all the affairs and interests of ERDDA shall be vested in a Board of Governors (hereinafter referred to as "the Board" or "the Governors"), composed of 15 members.

Eight of the Governors shall be Government officials as follows:

1. As Chairman of the Board, the official designated by the President as having primary responsibility for energy policy (subject to Senate confirmation if not already confirmed for his primary office);
2. The Director of the National Science Foundation;
3. An Assistant Administrator of the National Aeronautics and Space Administration, designated by the Administrator of that Administration;
4. An Assistant Secretary of Defense, designated by the Secretary of Defense;
5. A member of the Atomic Energy Commission (proposed hereinbelow to be renamed the "Nuclear Energy Commsssion"), designated by that Commission;
6. A member of the Federal Power Commission, designated by that Commission;
7. A member of the Council on Environmental Quality, designated by that Council;
8. The Administrator of ERDDA, appointed to that position in accordance with Section 107(b) below.

Seven Governors shall be appointed by the President with the advice and consent of the Senate, as follows:

1. A person with high qualifications and responsibilities in the coal industry whose appointment shall be made from a list of recommendations by the principal national organizations r presenting the coal industry;
2. A person with high qualifications and responsibilities in the nuclear power industry whose appointment shall be made from a list of recommendations by the principal national organizations representing the nuclear power industry;
3. A person with high qualifications and responsibilities in the natural gas industry whose appointment shall be made from a list of recommendations by the principal national organizations representing the natural gas industry;
4. A person with high qualifications and responsibilities in the petroleum industry whose appointment shall be made from a list of recommendations by the principal national organizations representing the petroleum industry;
5. A person with high qualifications and responsibilities in the electric industry whose appointment shall be made from a list of recommendations by the principal national organizations representing the electric industry;
6. A representative from the public at large with high qualifications and responsibilities for environmental concerns; and
7. A representative from the public at large with high qualifications and responsibilities for consumer concerns.

(b) The terms of the government members of the Board shall coincide with their terms in the offices here qualifying them to serve on the Board. The terms of the seven nongovernment members shall each be for 4 years subject to prior removal by the President, for cause, except that in order to provide staggered terms, the terms of 2 initial Governors, designated by the President, shall be for 3 years, the terms of 2 shall be for 2 years, and the term of 1 shall be for 1 year. Any Governor appointed to fill a vacancy occurring before the expiration of the term for which his predecessor had been appointed shall serve for the remainder of such term. Each Governor shall be reimbursed for travel and reasonable expenses incurred in attending meetings of the Board.

(c) 1. The Board shall meet quarterly and on call.

2. Vacancies in the Board, as long as there are sufficient members to form a quorum, shall not impair the powers of the Board.

3. The Board shall act upon majority vote of those members who are present, and any eight members present shall constitute a quorum for the transaction of business by the Board; except that a favorable vote of an absolute majority of

the Governors in office shall be required for the approval of annual budgets, and for the appointment, removal, and setting of compensation for the Administrator and Deputy Administrator.

ADMINISTRATOR: DEPUTY ADMINISTRATOR

SEC. 105. The Administrator of ERDDA, appointed pursuant to Subsection 107(a) below, shall serve as the Chief Executive Officer of the Administration, in accordance with Subsection 107(c) below. The Deputy Administrator, appointed under Subsection 107(a) below, shall be the alternate Chief Executive Officer. He shall act for and exercise the powers of the Administrator during his absence or disability.

GENERAL COUNSEL: ASSISTANT ADMINISTRATORS

SEC. 106. There shall be within the Administration a General Counsel, and such number of Assistant Administrators as the Board shall consider appropriate. The General Counsel and the Assistant Administrator shall be appointed by, and serve at the pleasure of the Administrator.

TITLE III

FUNCTIONS

SEC. 107. (a) The Board shall appoint the Administrator of ERDDA from a list of people recommended by the National Science Foundation, the National Academy of Science, and the National Academy of Engineering as highly competent to administer the important and complex energy research and development responsibilities of ERDDA. The Board shall also appoint the Deputy Administrator, and it shall have the power to remove the Administrator and the Deputy Administrator, and it shall fix their pay and terms of service.

(b) The Board may delegate its authority to the Administrator under such terms, conditions, and limitations, including the power of redelegation, as it deems desirable, and it may establish such Committees as it determines appropriate to carry out its functions and duties; such delegations shall be consistent with other provisions of this Act, shall not relieve the Board of full responsibility for carrying out its duties and functions, and shall be revocable by the Board in its exclusive judgment.

(c) The Administrator, as Chief Executive Officer of the Administration, shall be responsible to the Board for implementation of this Act and administration of ERDDA. He shall present an annual budget to the Board of Governors for their review and approval. After the Board has approved a budget, the Administrator may obtain specific moneys within it, from the fund established in Section 114 hereinbelow, by notice to the Secretary of the Treasury that such moneys are needed as of a certain date to carry out the program and budget approved by the Board.

(d) The Administration shall exercise central responsibility for policy planning, budgeting, initiation, coordination, support, and management of research and development programs respecting all forms of energy sources, including but not limited to those specified in Subsection (e) below. It shall be responsible for assessing the requirements for research and development in regard to various forms of energy sources in relation to near-term and long-range needs, for policy planning, and for budgetary and expenditure control to meet those requirements, for retaining, supporting, and where needed, strengthening effective existing programs, and for initiating new programs as needed for the optimal development of all forms of energy sources, from research through commercial-sized demonstrations, for providing appropriate priority and balance among nuclear, fossil fuel, geothermal, solar, and other energy research and development responsibilities, for managing such programs, for terminating them when their purpose has been accomplished or when they are no longer feasible, and for disseminating information resulting therefrom.

(e) The Administration shall have all the authority incidental, necessary, or appropriate to implementing its responsibilities, including without limitations, authorization:

1. to ensure that full consideration and adequate support is given to advancing energy research and development of efficient and environmentally acceptable energy sources, technologies, and techniques including but not limited to:

(i) coal gasification;
(ii) coal liquefaction;
(iii) solvent refined coal;

(iv) improved extraction methods and *in situ* conversion of fuels;
(v) advanced power cycle development;
(vi) shale oil development;
(vii) geothermal energy;
(viii) thermally-actuated heat pumps;
(ix) fuel cells and other direct conversion methods;
(x) solar energy;
(xi) hydrogen as an energy form;
(xii) nuclear breeder processes;
(xiii) fusion processes;
(xiv) magnetohydrodynamics;
(xv) use of agricultural products for energy;
(xvi) utilization of waste products for fuels;
(xvii) cryogenic transmission of electric power;
(xviii) electrical energy storage methods;
(xix) alternative to internal combustion engines;
(xx) wind power;
(xxi) tidal power; and
(xxii) ocean current and thermal gradient power;

2. to prescribe such policies, standards criteria, procedures, rules, and regulations as it deems necessary or appropriate.

3. to enter into such contracts and agreements, including grant agreements, with public agencies and private organizations and persons; to make payments therefor (in lump sum or installments, and in advance or by way of reimbursement, and with necessary adjustments on account of overpayments and underpayments).

4. to engage in joint projects of a reseach, developmental, and demonstration nature with public agencies and private organizations or individuals in the organizational form deemed appropriate, and to perform services with or for them on matters of mutual interest, the cost of such projects or services to be apportioned equitably by the Administration.

5. to acquire any of the following described rights if the property acquired thereby is for use by or for, or is useful to, the performance of functions vested in the Administration:

(i) copyrights, patents, and applications for patents, designs, processes, and manufacturing data;

(ii) licenses under copyrights, patents, and applications for patents;

(iii) releases, before suit is brought, for past infringement of patents or copyrights; and

(iv) use of Federal lands (except lands preempted for other use by Federal statutes) which contain energy sources which ERDDA determines are necessary to carry out its research and development functions and programs. The responsible officials of such other departments or agencies which have jurisdiction over Federal lands are hereby authorized and directed to make such lands available to ERDDA under terms and conditions promulgated by them to protect the environment and other resource values of lands involved.

6. to make special studies concerning matters within the special competence of the Administration; to prepare from the records of the Administration special compilations, lists, bulletins, or reports; to furnish transcripts or copies of such studies, compilations, and other records; to provide copies of charts, maps, or photographs, and to provide services incident to the conduct of the regular work of the Administration. The administration shall require payment of the actual or estimated cost of such special work in accordance with regulations prescribed by the President.

7. to exercise, in relation to the functions transferred herein, to the extent necessary or appropriate to perform such functions, any authority or part thereof available by law, including appropriations Acts, to the official or agency from which such functions were transferred.

(f) The Administration shall utilize or acquire the facilities of existing Federal scientific laboratories engaged in energy research and development; it shall also establish and operate additional facilities and test sites; and it shall utilize such services of contract agencies as it considers necessary to effectuate the purposes of this Act.

(g) The Administrator shall, as soon as practicable after the end of each fiscal year, submit a Report to the Board, and the Board shall submit a Report to the President for transmittal to the Congress, on the activities of the Administration during the preceding fiscal year, with a full accounting of receipts and expenditures, projects terminated and initiated, and plans and progress made in developing

new energy supply and in attaining the capability of energy self-sufficiency from domestic resources.

(h) The President, in the ninth year after the effective date of this Act, shall report to the Congress his evaluation of progress under it and his recommendation for continuance of the Federal energy research and development programs.

TITLE IV

TRANSFERS

SEC. 108. There are hereby transferred to and vested in the Administration such Federal energy research and development functions and programs as are essential to ERDDA's fulfilling its obligations under this Act. Without limitation, such transfer shall include:

(a) All energy research and development functions and programs of the Atomic Energy Commission and of the Chairman and members of the Commission except those pertaining to nuclear weapons or military use of nuclear power. The Atomic Energy Commission's research and development functions related to such military purposes shall be transferred to the Department of Defense, and the Secretary of Defense and ERDDA shall establish a special liaison committee to provide coordination, cooperation, and economy between the Department of Defense and ERDDA as to their respective research and development programs.

The remaining functions of the Atomic Energy Commission shall continue as provided in Section 115 below.

(b) All energy research and development functions and programs of the Secretary of the Interior, the Department of the Interior, and officers and components of that Department.

(c) The energy research and development functions and programs of such other Federal departments or agencies, including without limitation those in the Departments of Commerce, Transportation, Housing and Urban Development, and those in independent agencies such as the General Services Administration, the National Aeronautics and Space Administration, the National Science Foundation, and the Tennessee Valley Authority, as in ERDDA's judgment are necessary or appropriate for it to fulfill its responsibilities under this Act.

(d) Authority for reviewing and coordinating all other energy research and development functions and programs in Federal departments or agencies in the Executive Branch.

(e) Unexpended balances of appropriations, authorizations, allocations, and other funds relating to the functions transferred hereby to ERDDA shall be transferred as determined by the Director of the Office of Management and Budget in accordance with Section 109 below and with Section 202 of the Budget and Procedures Act (31 USC 581 (c)).

SEC. 109. (a) During the transition of transfers every effort shall be made to not in any way impede or impair the progress of current Federal energy research and development programs.

(b) Transfer of nontemporary personnel shall not cause any such employees to be separated or reduced in grade or compensation for one year after such transfer.

TITLE V

SAVINGS PROVISIONS

SEC. 110. All orders, determinations, rules, regulations, permits, contracts, certificates, licenses, and privileges which have been issued, made, granted, or allowed to become effective by the President, any Federal department or agency or official thereof, or by a court of competent jurisdiction, in the performance of functions which are transferred by this Act, and which are in effect at the time this Act takes effect, shall continue in effect according to their terms until modified, terminated, superseded, set aside, or revoked by the President, the Administrator, or other authorized officials, a court of competent jurisdiction, or by operation of law.

SEC. 111. (a) The provisions of this Act shall not affect any proceedings pending at the time it takes effect before any department or agency, or component thereof, functions of which are transferred by the Act, but to the extent such proceedings relate to functions so transferred, they shall be continued. Orders shall be issued in such proceedings, appeals taken therefrom, and payments made pursuant to such orders, as if the Act had not been enacted; and orders issued in any such proceedings shall continue in effect until modified, terminated, superseded, or revoked by a duly authorized official, by a court of competent jurisdiction, or by operation of law. Nothing herein shall be deemed to prohibit the discontinuance or

modification of any such proceeding under the same terms and conditions and to the same extent that such proceeding could have been discontinued if the Act had not been enacted.

(b) Except as provided in Subsection (d)—

1. the provisions of this Act shall not affect suits commenced prior to the date this Act takes effect, and

2. in all such suits proceedings shall be had, appeals taken, and judgments rendered, in the same manner and effect as if the Act had not been enacted.

(c) No suit, action, or other proceeding commenced by or against any officer in his official capacity as an officer of any department or agency whose functions are transferred by the Act shall abate by reason of enactment of the Act. No cause of action by or against any department or agency, functions of which are here transferred, or by or against any officer thereof in his official capacity shall abate by reason of the enactment of this Act. Causes of actions, suits, actions, or other proceedings may be asserted by or against the United States or such official as may be appropriate and, in any litigation pending when this Act takes effect, the court may at any time, on its own motion or that of any party, enter any order which will give effect to the provisions of the Act.

(d) If, before the date on which this Act takes effect, any department or agency, or officer thereof in his official capacity, is a party to a suit involving any function of such department, agency, or officer transferred by this Act to the Administration, then such suit shall be continued as if this Act had not been enacted, with the Administration substituted.

(e) Final orders and actions of any official or compenent in the performance of functions transferred by this Act shall be subject to judicial review to the same extent and in the same manner as if there had been no transfer. Any statutory requirements relating to notices, hearings, action upon the record, or administrative review that apply to any function transferred hereby shall apply to the performance of those functions by the Administration, or any officer or component.

Sec. 112. With respect to any function transferred by the Act and performed after its effective date reference in any other law (including reorganization plans) to any department or agency or any officer or office the functions of which are so transferred shall be deemed to refer to the Administration of officials thereof in which this Act vests such functions.

Sec. 113. Nothing herein shall be construed to limit, curtail. abolish, or terminate any function of the President which he had immediately before the effective date of the Act; or to limit, curtail, abolish, or terminate his authority to perform such function; or to limit, curtail, abolish, or terminate his authority to delegate, redelegate, or terminate any delegation of functions.

TITLE VI

FUNDING

Sec. 114. (a) There is hereby established in the Treasury of the United States a trust fund to be known as the Federal Energy Research, Development, and Demonstration Trust Fund (referred to herein as the "fund"). The fund shall consist of such amounts as may be credited or appropriated to it as provided in this section, and moneys so credited or appropriated are hereby made available to ERDDA for carrying out the purposes of this Act including the administration thereof, without fiscal year limitations.

(b) Commencing with the fiscal year ending June 30, 1974, and each fiscal year thereafter, all revenues (except so much thereof as may be already obligated under the provisions of other legislation such as Section 2(c)(2) of the Land and Water Conservation Fund Act of 1965 (16 U.S.C. 4601–5) due and payable during each such fiscal year to the United States for deposit in the Treasury as receipts from Federal lease sales of all energy sources, as well as royalties and other revenues derived from operations on, or the use, of such Federal leases, shall, up to $2,000,000,000, be credited to the fund.

(c) In addition to the moneys credited to the fund pursuant to Subsection (b) of this section, there is authorized to be appropriated to the fund for the fiscal year ending June 30, 1974, and each fiscal year thereafter, such amount as is necessary to make the income of the fund $2,000,000,000 for each such fiscal year.

(d)(1) It shall be the duty of the Secretary of the Treasury to manage the fund and (after consultation with appropriate officials of ERDDA) to report to the Congress not later than the first day of March of each year on the financial condition and the results of the operations of the fund during the preceding fiscal year and on its expected condition and operations during each fiscal year there-

after. Such report shall be printed as a Senate and House document of the session of the Congress to which the report is made.

(2) It shall be the duty of the Secretary of the Treasury to invest such portion of the fund as is not, in his judgment, required to meet current withdrawals. Such investments may be made only in interest-bearing obligations of the United States or in obligations guaranteed as to both principal and interest by the United States. For such purpose such obligations may be acquired (A) on original issue at the issue price, or (B) by purchase of outstanding obligations at the market price. The purpose for which obligations of the United States may be issued under the Second Liberty Bond Act, as amended, are hereby extended to authorize the issuance at par of special obligations exclusively to the fund. Such special obligations shall bear interest at a rate equal to the average rate of interest, computed as to the end of the calendar month next preceding the date of such issue, borne by all marketable interest-bearing obligations of the United States then forming a part of the public debt; except that where such average rate is not a multiple of one-eighth of 1 per centum, the rate of interest of such special obligations shall be the multiple of one-eighth of 1 per centum next lower than such average rate. Such special obligations shall be issued only if the Secretary of the Treasury determines that the purchase of other interest-bearing obligations of the United States, or of obligations guaranteed as to both principal and interest by the United States on original issue or at the market price, is not in the public interest.

(3) Any obligation acquired by the fund (except special obligations issued exclusively to the fund) may be sold by the Secretary of the Treasury at the market price, and such special obligations may be redeemed at par plus accrued interest.

(4) The interest on, and the proceeds from the sale or redemption of, any obligations held in the fund shall be credited to and form a part of the fund.

TITLE VII

NUCLEAR ENERGY COMMISSION

SEC. 115. (a) The Atomic Energy Commission shall retain its functions pertaining to uranium and thorium reserve assessment, and its functions pertaining to the licensing and related regulatory functions of the Chairman and members of the Commission, the General Counsel, and other officers and components of the Commission performing such functions, which functions, officers, and components are not included in the transfer to the Administrator by section 108 above.

(b) The Atomic Energy Commission is hereby renamed the Nuclear Energy Commission.

TITLE VIII

EFFECTIVE DATE AND INTERIM APPOINTMENT

SEC. 116. The provisions of this Act dealing with title II (sections 103, 104, 105, and 106) shall take effect on the day of enactment. All other provisions shall take effect thirty days thereafter. Funds available to any department or agency (or any official or component thereof), any functions of which are transferred to the Adminlstration by this Act, may, with the approval of the President, be used to pay the compensation and expenses of any officer appointed pursuant to this subsection until such time as funds for that purpose are otherwise available.

TITLE IX

DEFINITIONS AND ADMINISTRATIVE PROVISIONS

SEC. 117. (a) As used herein references to:

1. "function" or "functions" include references to duty, obligation, power, authority, responsibility, right, privilege, and activity, or the plural thereof, as the case may be.

2. "perform" or "performance" when used in relation to functions, include the exercise of power, authority, rights, and privileges.

3. "research and development" include all phases of Federal energy research, development, and demonstration, ranging from the conception of scientific and engineering principles appropriate for attaining a particular technological objective through the demonstration of their practical utility on a commercial scale, except to the extent they are for military purposes;

4. "demonstration" refer to that stage of a research and development program which typically follows the pilot plant stage and the objective of which is to establish the commercial feasilbility of a particular process before it is put into commercial use;

5. "energy sources" includes fossil fuels, geothermal energy, nuclear energy, solar energy, tidal energy, and other unconventional sources of energy;

6. "person" include any individual, association, institution, corporation, or other entity, any state or political subdivision, or agency or institution thereof, and any Federal department or agency;

7. "the Act" or "this Act" refer to the "Energy Research, Development, and Demonstration Act" enacted herein;

8. "the Administration" or "ERDDA" refer to "the Energy Research, Development, and Demonstration Administration" established herein; and

9. "fund" refer to the Federal Energy Research, Development and Demonstration Trust Fund established herein.

Any reference to any provision of law shall be deemed to include, as appropriate, references thereto as now or hereafter amended or supplemented.

(b) The Administrator is authorized to accept, hold, administer, and utilize gifts, and bequests of property, both real and personal, for the purpose of aiding or facilitating the work of the Administration. Gifts and bequests of money and proceeds from sales of other property received as gifts or bequests shall be deposited in the Treasury and shall be disbursed upon the order of the Administrator. Property accepted pursuant to this section, and the proceeds therefo, shall be used as nearly as possible in accordance with the terms of the gift or bequest. For the purpose of Federal income, estate, and gift taxes, property accepted under this section shall be considered as a gift or bequest to the United States.

(c) The Administration shall cause a seal of office to be made of such device as the Board shall approve, and judicial notice shall be taken of such seal.

TITLE X

SEPARABILITY

Sec. 118. If any provisions of this Act, or the application thereof to any person or circumstance is held invalid, the remainder of the Act, and the application of such provision to other persons or circumstances shall not be affected thereby.

A Bill To Establish an Energy Research, Development, and Demonstration Administration

The attached proposed legislation is based on the conviction that a substantially increased centralized, and sustained energy research and development program, including demonstration, is indispensable to development of the nation's domestic energy sources, and thereby its energy self-sufficiency, through socially and environmentally accepted methods for producing, conserving and utilizing all forms of energy. Accomplishment of this vital effort requires a fresh new organization independent of existing organizations and procedures, and charged with overall and specific accountability for coordination, streamlined administration, and results.

The bill accordingly provides for the establishment of a new independent agency, the Federal Energy Research, Development, and Demonstration Administration ("ERDDA"). Responsbility is consolidated therein for coordinating and administering all existing, and for initating, coordinating and administering extensive new, energy research and development functions and programs applicable to all forms of energy—except those undertaken for military purposes. Commensurate authority extends from overall policy planning and budget control, to all stages of particular projects, from initial conception through design, construction, operation and maintenance of commercial-sized demonstration plants, such operations to be carried on internally with ERDDA's own facilities, or by suitable arrangement with contract agencies.

A 15-member Board of Governors, composed of Government Officials qualified in energy and energy research and development, and of experts from the private sector, is responsible for overall supervision of ERDDA. The daily operations of ERDDA are to be directed by an "Administrator," who must be outstandingly qualified in those fields, and their management. He will serve as Chief Executive Officer responsible to the Board for carrying out the Board's policies consistent with the objectives and purposes of the Act.

To carry out this effort, the bill provides for funding through a special trust fund composed of receipts from Federal lease sales and all other sales or grants of development rights of energy sources on Federal lands, up to $2 billion a year. The payments to the Federal Government for energy development rights thus earmarked for development of new energy sources would provide the sustained continuity indispensable to a project of this nature.

APPENDIX B

S. 2744	S. 2694	Comments
1. Findings:	§ 101 (a) Critical shortage of environmentally acceptable forms of energy. (b) Major reason is lack of aggressive energy research, development, and demonstration effort to develop national capability for energy self-sufficiency. (c) Current uses of energy inefficient. (d) Funding inadequate and too fragmented. (e) Capital requirements of total R. & D. programs beyond means of private sources. (f) National commitment of highest priority needed.	S. 2694 specifically states urgency of problem. It is necessary to inform public as well as Congress how this legislation relates to that problem. S. 2744 deficient on this.
2. Purpose: § 2 (a) Need development and more efficient use of all energy sources to meet present and future needs, increase productivity of economy and strengthen it in international trade, make nation self-sufficient in energy and advance environmental goals.	§ 102 (a) Undertake a national commitment to resolve energy shortage and provide means for achieving national capability for energy self-sufficiency.	(a) S. 2694's specification of a national commitment in keeping with need and desirable for reasons above as to "Findings."
(b) Necessary to establish an Energy Research and Development Administration (ERDA) to bring together and direct Federal activities relating to R. & D., to increase efficiency and reliability in use of energy, and to carry out performance of other functions, including military and production activities.	(b) Consolidate and strengthen existing and initiate new Federal programs for energy research and development in an Energy Research, Development, and Demonstration Administration (ERDDA).	(b) S. 2694's more ambitious goals are more in line with the Nation's need. S. 2744's mixing military and production activities in with energy R. & D. is not desirable.
(c) Separate licensing and related regulatory functions of AEC from other functions transferred herein to ERDA.		
3. Establishment: § 101 Independent executive agency: Energy Research and Development Administration (ERDA).	§ 3 Independent executive agency: Energy Research, Development, and Demonstration (ERDDA).	We favor S. 2694's emphasis on the all important "demonstration' phase, with its inherent high-cost and high-risk nature.
4. Organization: § 102 (a) At head: Administrator, executive level II. (b) Deputy Administrator, executive level III. (c) 5 Assistant Administrators, responsible respectively for fossil fuel, environment, safety and conservation, research and advanced energy, and national security, executive level IV. (The Administrator, Deputy Administrator, and 5 Assistant Administrators are to be appointed by President with advice and consent of Senate.) (d) General Counsel, executive level V. (e) No more than 7 additional officers at executive level V. (f) Director of Military Applications—at general or flag officer rank.	§ 104 Board of Governors: 8 Government officials, 7 from private sector. § 105 Administrator serves as chief executive officer, under Board. § 107 (a) Board sets compensation of Administrator and Deputy Administrator. § 106 General Counsel and as many Assistant Administrators as Board approves, appointed by Administrator.	S. 2744: Responsibilities involved are too much to center in 1 man. Compensation at executive levels is inadequate to attract the talent needed. S. 2694 which lets Board set Administrator's and Deputy's compensation (§ 107) is necessary to attract competent talent. S. 2694 provides better balance: Overall management in a highly qualified Board, which provides expertise from key segments of Government and industry, with Administrator, the chief executive officer, in charge of day-to-day operations.

5. Functions: § 103 Broad responsibility for (1) overall policy planning, coordination, support and management of R. & D. programs respecting all energy sources; (2) encouraging and conducting R. & D. to demonstrate the commercial feasibility of energy sources and utilization technologies; (3) undertaking R. & D. in the extraction, conversion, transmission, and utilization phases related to the development and use of energy from fossil, nuclear, solar, geothermal, and other energy sources; (4) engaging in and supportingn evironmental, biomedical, physical, and safety research related to the development of energy sources and utilization techniques; and (5 to 7) correlating its R. & D. programs with other private and public R. & D. activities, supporting cooperative R. & D. and developing and making available its information.	§ 107 (c) Administrator, as CEO, responsible to Board. Presents annual budget for Board approval, with which he may obtain specific moneys from trust fund established in § 114. (d) Administration to exercise central responsibility for all phases of energy R. & D. (except military applications), existing and new, and including demonstration stages, by contracts, joint projects, or in its own facilities.	The broad responsibilities of the respective Administrations are approximately the same, but S. 2694 is more specific as to the means by which the Administrator may proceed (§ 107(d)) and as to the areas he is expected to cover (§ 107(e)).
The Administrator's implementing powers are set forth in § 108 (powers), and certain additional powers are included in § 106 (administrative) and § 107 (personnel).		The implementing powers of each bill are reasonably similar, but S. 2744's basic implementing power as to demonstration projects (§ 108(a)) seems attuned more to academic than practical benefits. The functions of the Administrator in each case are determined in considerable part by the functions of existing agencies transferred to him, covered below.
6. Transfer of functions: § 104 (a) All functions of AEC (including military energy R. & D.) except licensing and related regulatory functions (§ 201) and except that the renamed Nuclear Energy Commission may engage in research which it deems necessary for the discharge of its licensing and regulatory functions (including those specified at § 202), as to which ERDA and all other Federal agencies, shall cooperate to the extent practicable.	§ 108 ". . . such Federal research and development functtions and programs as are essential to ERDDA's fulfilling its obligaions under this Act," including: (a) All energy R. & D. functions of AEC except that relating to nuclear weapons or military use of nuclear power.	While S. 2744 transfers most existing Federal energy R. & D. programs and functions to the new agency, it leaves many fragmented programs and functions in place. That would make it difficult for the new agency truly to coordinate and implement policy for all energy R. & D. S. 2694, in addition to transferring all AEC energy R. & D. functions (except military) (§ 108 (a)) and all Interior energy R. & D. functions (§ 108 (b)), provides flexibility for the Administrator of ERDDA to acquire those functions and programs needed in its judgment for it to accomplish its purpose (§ 108 (c)), and gives him needed authority for reviewing and coordinating all other energy R. & D. functions. S. 2694 is thus more mission oriented and so more responsive to the need. We also disagree with S. 2744's mixing responsibility for military and civilian energy R. & D. in ERDA. While transitional matters are treated substantially the same, by both bills, S. 2694 specifically provides that during the transfers the progress of current programs shall not be impaired. That is a useful addition and we support it.
(b) Interior functions relating to: (1) OCR. (2) Bureau of Mines fossil fuel R. & D. (3) Underground electric power transmission research.	(b) All Interior energy R. & D. functions.	
(c) National Science Foundation functions relating to: (1) Solar heating and cooling development. (2) Geothermal power development.	(c) Energy R. & D. functions of such other Federal departments or agencies as, in ERDDA's judgment, are necessary or appropriate for it to fulfill its responsibilities.	
(d) EPA functions relating to development and demonstration of: (1) Alternative automotive power systems. (2) Precombustion, combustion, and postcombustion technologies to control emissions from stationary sources using fossil fuels.	(d) Authority for reviewing and coordinating all other Federal energy R. & D. functions and programs.	

S. 2744	S. 2694	Comments
7. Funding:		
§ 304 "Except as otherwise provided by law, appropriations made under this Act shall be subject to annual authorization."		S. 2744 thus provides no specific funding, but requires ERDA to go before Congress every year with a proposed budget. The practica effect will be to subject what should be an objective scientific and mission-oriented agency to a high degree of politics. It converts the basic thrust of the effort from one where the agency should be encouraged aggressively to innovate and prosecute potential programs under a sustained funding level, to one where it cannot move without prior congressional budget approval on many projects which when considered on a political basis can become highly controversial and so vulnerable to delay, disruption, and blunted initiative.
	§ 114 (a) Establishment of Federal energy research, development, and demonstration trust fund (the "fund"); moneys credited to which are made available to ERDDA for carrying out the purposes of this act, without fiscal year limitations.	S. 2694 is far superior as to funding in that is specifies a particular funding level, and in that it provides it on the sustained basis needed for this kind of program. It would enable ERDDA to operate with the innovation and continuity the program must have 6 if it is to do the difficult and important task involved in providing a national capability for self-sufficiency.
	(b) Up to $2,000,000,000 a year shall be credited to the fund from revenues due the Treasury as receipts from Federal lease sales of all energy sources, royalties, and other revenues from operations on or the use of such leases.	It is also equitable since it basically earmarks funds derived from the sale of Federal energy development rights for a program to provide new energy sources desperately needed by the Nation and individual consumers of energy.
	(c) There is also authorized to be appropriated for fiscal 1974 and each fiscal year thereafter such amount as is necessary to make the income to the fund $2,000,000,000.	It is unlikely that this general appropriation (§ 114 (c)) will be needed, but it is a proper safeguard.
8. Nuclear Energy Commission:		
§ 201 Atomic Energy Commission renamed Nuclear Energy Commission, with retained functions as to licensing and related regulatory functions, including (§ 202) licensing authority over certain demonstration facilities in liquid metal fast breeder reactors and other demonstration nuclear reactors, and facilities used primarily for receipt and storage of high-level radioactive wastes resulting from AEC licensing activities. § 203 Research—retained as it affects licensing, per above.	§ 115 AEC renamed NEC, with retained functions as to uranium and thorium assessment and as to licensing and related regulatory functions. All nonmilitary R. & D. presently in AEC is transferred to ERDDA.	We support S. 2694's more inclusive transfer to ERDDA of AEC's civilian energy R. & D., and without its military energy R. & D.

PRIVATE INDUSTRY INVOLVEMENT IN ENERGY R. & D.

Senator RIBICOFF. Mr. Partridge, ERDA would initiate a strong Federal initiative in the field of energy research. How much energy research should ERDA be responsible to and how much should private energy research be responsible for on its own?

Mr. PARTRIDGE. Well, in the first place, I do not think the Government should be doing any Federal energy research, in theory, and in fact, and basically this is wrong.

Nevertheless, the situation has gotten so out of hand that the only way that the problem can be met in an expeditious fashion is for the Government to take the major lead in the funding. I would hope, as the activity of ERDA develops, that there would be strong industry participation in many of the projects.

Senator RIBICOFF. It is intended that there be participation from the private sector. Mr. Ash did testify yesterday and thought that the overall research cost that he has in mind for the next 5 years, would be in the nature of $10 billion Federal and $12½ billion private.

Both coordinating, whether on a crash basis, there is a question whether at this late date you can depend upon private industry to make that huge investment now.

Mr. PARTRIDGE. I agree, that is a big question.

NATURAL GAS INDUSTRY INVOLVEMENT IN RESEARCH

Senator RIBICOFF. Let me ask you: How much research is the natural gas industry apt to be doing itself?

Mr. PARTRIDGE. At the present time, as an industry, we are doing something between $50 and $75 million a year, which is a pittance. Nevertheless, that is the fact of life. I would question, except for specific projects, considering the condition of the natural gas industry. The great majority of the industry, as you probably know, has a complete freeze on any new sales, residential or otherwise. I would question very much whether you can expect anything more than what you are presently doing, from the industry.

But, project by project, then, it has to be developed. For example, in connection with coal gasification, if we reach the point where we are ready to get going with a demonstration plant, then certainly we must try to get the strongest industry participation and finance in that particular area.

INVESTMENT FROM PRIVATE COMPANIES

Senator RIBICOFF. Do you think that the companies that make up your association would be willing to invest the money to construct plants to extract gas from coal?

Mr. PARTRIDGE. They certainly will, once the technology has proven feasible.

Senator RIBICOFF. In other words, you would expect that the initiative and the working out of the cost of the technology of doing it would come from the Government and industry in a cooperative effort?

Mr. PARTRIDGE. Yes, sir.

Senator RIBICOFF. What types of incentives do you think would be important to encourage the gas industry to take a bigger bite of this whole picture?

Mr. PARTRIDGE. I do not think that tax incentive, other than what we presently have on drilling and so forth, would mean very much. You see, we are a regulated industry. All we really do with tax incentives, the customer, in turn, does pay for them. I would question whether a tax incentive——

Senator RIBICOFF. You do not think it would mean anything to you?

Mr. PARTRIDGE. No, I do not, sir.

Senator RIBICOFF. Let me ask you, what area of research holds out the most promise for producing new sources of natural gas?

Mr. PARTRIDGE. At this time, it is coal gasification.

If I could take just a minute, you may be aware that the natural gas industry and the Department of the Interior are in the third year of a joint project on coal gasification. This is much further advanced than any other research on synthetic gas that we know of. This holds the promise of coming to fruition much more quickly than we think. We definitely think that coal gasification provides the earliest opportunity for any appreciable relief, from research.

IS AN INVESTMENT IN RUSSIA FOR GAS A GOOD IDEA?

Senator RIBICOFF. Do you know that there has been a lot of talk of a deal between the United States and the Soviet Union for the setting up of an arrangement to liquefy gas, bring it over here in tankers, then turn it into gas again? It is estimated that the cost of that entire project would be the equivalent of $18,000 for a barrel of oil. It has been estimated by experts that we had here yesterday, that for the investment of $5,000 for a barrel of oil, you could get all the oil that you need here in the United States from alternate sources. Do you see any justification for the United States making that investment of $18,000 a barrel of oil, dealing with the Soviet Union who could close that tap on us at any time, as the Arabs and the Algerians have, do you think that makes any sense from a business standpoint?

Mr. PARTRIDGE. Absolutely not. It would be a great mistake.

Senator RIBICOFF. It would be a great mistake to go into a deal like that?

Mr. PARTRIDGE. Yes. Let me comment on the statement you made—all the oil that we can possibly use. I do not think that is correct.

OIL IS A FINITE SUBSTANCE

Senator RIBICOFF. I am talking energy, the alternate sources. I am not talking about oil, because I think oil is a finite substance. We can only make ourselves sufficient in alternate sources of energy.

Mr. PARTRIDGE. All right, I do want to make the point that we have to face up to the fact that there is a finite level to fossil fuels. This would be a great function of the new energy research effort to develop, other than fossil fuels.

SHORT-RANGE GAS SHORTAGE

Senator RIBICOFF. Let me ask you how much of a natural gas shortage do your companies face this winter, and for the immediate future?

Mr. PARTRIDGE. This winter, I think that the curtailment based upon a normal winter, is something in the area of 18 or 20 percent.

Mr. LAWRENCE of A.G.A., from the audience. I think that, Mr. Partridge, we have certain companies that are curtailing as much as 33 percent. I think the nationwide contract curtailment of actual contract terms are in the range of 6½ percent of the contract commitments. Now the gap between what is supplied and what the demand might be, which is something larger than existing contract requirements, could very well approach the figure that Mr. Partridge stated.

Senator RIBICOFF. I am curious, when we have a mild November and the first few days of December, how much does that save from our reservoir of gas and oil, have you any idea?

Mr. PARTRIDGE. No, sir, I do not know the figures. Most winters average it out.

Senator RIBICOFF. One way or the other, they average out?

Mr. PARTRIDGE. When you have a mild November and December, you usually get it in January and February.

CONSUMER CONSERVATION

Senator RIBICOFF. I am curious, has your association ever done a study of how much the gas is wasted by the consumers in this country that could be saved by conservation measures?

Mr. PARTRIDGE. I do not know any figures on that. Certainly for the last several years, most gas companies have had strong conservation growth. I know that my own company, for many years, has been urging such things as insulation, storm windows, and proper thermostat settings.

Senator RIBICOFF. Have your customers been listening to you?

Mr. PARTRIDGE. Not too much until recently.

Senator RIBICOFF. Are they now?

Mr. PARTRIDGE. Yes, they are.

Senator RIBICOFF. On a voluntary basis, do you think that the American people are changing their wasteful habits?

Mr. PARTRIDGE. To some degree, not as much as I would like to see.

Senator RIBICOFF. What is your thought about replacing natural gas use by coal to the fullest extent possible and save the supply of natural gas we have, over a period of time? You have never had to think of that before because your business was solely gas, in competition with other fuels.

Since there is a finite quantity of all these items, how do you think we ought to do it?

Mr. PARTRIDGE. I think there is definitely a place, or an area, for each form of energy. There is not any question that natural gas is a premium for certain uses. I also think that we have to keep in mind, I mentioned it earlier in my testimony, that we have a $50 billion investment and over 1 million miles of pipeline which should not be allowed to be idle. And, again, we are talking about we know that pipeline transportation of gas is by far the most efficient way to transport energy.

Senator RIBICOFF. That is true, but how are we going to get more gas? How do you suggest we get more gas to keep your pipelines going and your investment to pay off?

Mr. PARTRIDGE. We have to see to it that the proper incentives for adequate drilling are established. We have to see to it that the Federal offshore lands are made available on a greatly accelerated basis for this drilling. We have to get busy to bring gas from the Arctic into the United States. Then we have to have coal.

Senator RIBICOFF. What tax incentives would you recommend to make your industry drill or explore for more gas? What incentives do you want?

DEREGULATION

Mr. PARTRIDGE. It is not an incentive—what we must have is deregulation, or letting new gas seek its free market place.

Senator RIBICOFF. You are differentiating between new gas and old gas?

Mr. PARTRIDGE. Yes, sir.

Senator RIBICOFF. Your thought is that there ought to be a two-tier system, a series of incentives for new production of gas and oil, as against the present supply which you think the regulation ought to stay with?

Mr. PARTRIDGE. Yes, sir. I think that there ought to be an orderly transition. The proper way to do it, if we had had no regulation in the fuel process, if the Supreme Court decision in 1954 had not taken place, we would not be in the mess that we are in now. We have to have an orderly transition.

I would favor letting the life of the old gas contracts run out and let them be picked up again in accordance with new gas. I think that that way the economic impact would be greatly lessened.

Senator RIBICOFF. Even if that were done, where would you get the new gas from? If you deregulate it, where in this country would you get the new gas from now?

Mr. PARTRIDGE. There is a great deal of potential area to be explored in the Gulf of Mexico and one of the areas with tremendous promise is the offshore of the Atlantic coast. This runs all the way from Florida to New Foundland. The geology there looks great. I think the chances are very promising that tremendous amounts of hydrocarbons can be found there.

Senator RIBICOFF. If gas could be regulated with new exploration, do you think that private industry would do that all on their own and be able to get the capital together to do it?

Mr. PARTRIDGE. Well, yes, sir—no question.

Senator RIBICOFF. Do you think that higher taxes should be levied to discourage gas consumption?

ALTERNATE FUEL FOR GAS

Mr. PARTRIDGE. No, sir, I do not. Again, some way has to be found to stop gas from being used for what I would call inferior uses. But the problem is that there is a shortage of all forms of energy. Here you have got a huge electric utility generator that burns gas, you cannot just stop gas going to them because they cannot get an alternate fuel. This is a fact of life today. So that even if you say that the gas

to be burned, under boilers, should be taxed, I do not think that that is the answer to the problem. You are just going to shut down needed industry and so forth by doing it. Even by paying the additional tax, they cannot find an alternate fuel.

Then I think there is one more factor that should be considered. Any additional taxes, and so forth, eventually finds its way to the consumer in one form or another.

Senator RIBICOFF. Let me ask you—from what you anticipate the curtailment of gas to your customers, have you also thought out or anticipated or researched, its impact on industrial activity and unemployment among your customers?

Mr. PARTRIDGE. We have not done any specific research on that, per se. The industrial customers will be the first ones that will be cut off with vast unemployment. Again, the fact is that there are no other fuels that they can turn to. In turn, though, it is a chain effect of this that snowballs. Once you shut down this plant who makes parts for this plant, shut that plant down even though they may have adequate fuel, and that in turn shuts down another plant, this is going to be the horrible part of this when it really starts to unfold.

Senator RIBICOFF. Senator Roth?

Senator ROTH. Thank you, Mr. Chairman, I am sorry I could not be here from the beginning. I would like to express publicly my appreciation to Mr. Partridge, coming down here and testifying.

I would just like to say, that when everybody is looking for a scapegoat, Mr. Partridge, for many years, has been warning the United States about the impending energy crisis. That should be publicly recognized, and I appreciate the statesmanlike position he has been taking in this area.

FINANCING A $2-BILLION-A-YEAR TRUST FUND

Mr. Partridge, one question I would like to go back to, maybe some some of these have been taken up already, is where you talk about a trust fund of $2 billion a year in your testimony. If I recall, you also mentioned in your testimony that this could come from lease sales and oil leases. Do you feel that there will be a shortfall in this area if we should rely upon these areas as our sole source of revenue in a trust fund? Do you think we might have to add other sources of revenue?

Mr. PARTRIDGE. No, sir, I do not. Again, as I mentioned earlier, one activity that has to be accelerated is the leasing of Federal lands. There is good movement in this direction. The Department of the Interior is heading this way. This just has to be done. There is no question in my mind whatsoever that it should be very easy to get at least $2 billion, probably a lot more, for these next coming years.

Senator ROTH. There has been a lot of talk that as an interim R. & D. measure, we might adopt something like S. 1283. I just wonder whether you feel that it is appropriate to take interim measures at this time, or should we move full speed ahead to develop some special agency to take over now?

Mr. PARTRIDGE. The longer we take interim measures, not only on research but on the other energy problems, the longer this country's agony is going to extend. I am not sure but that there is even a geometric effect there. For every day that we waste right now, we might

just extend it 2 days longer. We have got to bite the bullet and get going on what has to be done.

Senator ROTH. Before Congress goes home this Christmas?

Mr. PARTRIDGE. Yes, sir. If you do it the right way.

INTERNATIONAL RESEARCH

Senator ROTH. One of the things that has interested me is how our country, Western Europe, and Japan might cooperate on energy R. & D. Do you have any thoughts or recommendations on what we might do in a joint effort with these countries? Do you think that it would be desirable for us to somehow provide in this legislation specifically that there should be cooperation and sharing of both cost and benefits with these other areas, Europe and Japan?

Mr. PARTRIDGE. This is an excellent idea. This would be a fine amendment. Certainly we do not have all the talent in the United States. Again, this is a worldwide shortage. I think this is an excellent idea, to arrange for the exchange and certainly you could avoid duplication of certain efforts. I think this is excellent.

Senator ROTH. I suppose one of the problems that we have at least at this moment in trying to do so is with some of our foreign friends who may be afraid that this would be misconstrued by the Arab nations. I have thrown this idea out at some joint Japanese-American meetings. While they are interested, there is some concern as to the Arab reaction.

Just following through on that, do you have any specific thoughts as to how we could approach this joint effort? Should it be just an exchange of information? Do you think it would be helpful to create a special office? Or do you have any thoughts on organizational structure at the moment concerning international cooperation?

Mr. PARTRIDGE. I do not, but certainly a section could be established in the new research organization which could provide this. It is something that should be studied, It should go further than just an exchange. As I said before, an effort should be made to see that we are not duplicating certain efforts and assign certain efforts to certain countries. This, I think, needs some study, but I think you could put some general provisions in the proposed legislation that would just see to it that this is done.

Senator ROTH. In other words, we should not just exchange but in the planning, really, if I understand what you are saying, we ought to sit down and sort of try to allocate in some manner, areas of responsibility where perhaps we all want to work simultaneously, but perhaps one country or another has some expertise that would give some reason for them being given the primary responsibility?

Mr. PARTRIDGE. Exactly.

DEPLETION ALLOWANCE

Senator ROTH. One of the concepts that has come up, I do not know whether you are familiar with it at this time, or would want to comment on it, but the suggestion has been made that the depletion allowance might somehow be buttressed or based upon industry—how much industry spends of that money, say taxwise on new capital expenditure. Have you given any thought, or do you care to comment

on that possible approach? In other words, you would not get the depletion allowance unless and to the extent that these funds generated are used for capital expenditures, possibly research by private industry.

Mr. PARTRIDGE. The depletion allowance, as it presently stands now, is certainly an incentive to the hydrocarbon industries to drill. If you can replace that with a better incentive, or one equally as good, I would have no problem with it. I do want to say certainly nothing should be done right at this critical time, to take away any incentives. I am not at all sure that by saying that you have to do certain of these, whatever you gain by the depletion allowance, to plow it back in, I think that would be taking away some of the incentive.

I go back again, Senator, to the very essential things that have to be done in connection with the hydrocarbon industries. That is, to provide the fullest incentives and let these products seek their fair, right, and proper marketplace. This is the only way in the long form that this is ever going to work out.

Senator ROTH. Back to the old supply and demand theory?

Mr. PARTRIDGE. Yes, sir, exactly.

Senator ROTH. One further question.

What should be the role of the private industry in the research and development area?

ROLE OF PRIVATE INDUSTRY IN R. & D.

For example, you read newspaper articles and so forth that the profits of at least some of the energy companies, oil companies in particular, are higher than they ever have been. Here I think you are talking about a $2 billion a year effort on the part of the Government.

How should that be supplemented?

What role, and how much do you think we should expect to be generated by private industry?

Mr. PARTRIDGE. My answer to a similar question from Senator Ribicoff earlier, I believe I can summarize by saying that I think this has to be done almost by a case by case proposition. I do not think that you can expect too much additional money from industry over what they are doing on their own right now, except as particular projects, demonstration plants or possibly even pilot plants, things like that coming along. There I think you will find industry interest, and I think quite properly industry should supply part of these funds.

Senator ROTH. I have not seen any figures, but I do assume that the amount of dollars being spent on research might be quite considerable not only in the energy industry, but related industries as well.

How do you see the private effort and the public effort going hand in hand?

Should there not be some mechanism in the legislation, for example for coordination and cooperation, or should we leave that pretty much up to the officials?

Mr. PARTRIDGE. No, sir. There is no provision in S. 2694 that provides or charges the new Government Federal Research Administration to see to it that the system—this is very essential again, to avoid duplication and provide cooperation.

Again, you are going to find that there is going to be quite a bit of private energy research being done on a proprietary basis. Nevertheless, even though it is proprietary and so forth, you can still coordinate and try to avoid duplication.

Senator ROTH. Have you given any thought, or do you have any ideas, as to exactly how the Government should commercialize any developments in this area?

In other words, if the Government spends $20 billion, let us say, in 10 years—I assume you agree with that figure. Whatever it is, it is cheap compared to whatever the balance of payment problem may be in the future.

Can we recapture these public funds by the licensing much as private industry does?

Have you given, has your association given any thought to this problem?

Mr. PARTRIDGE. You could. I am not sure that is good. I am not sure that it is necessary. I think that you will find that the major expenditures under this massive program are going to be in commercial demonstration plants. These are going to be the large projects, $300 million, $500 million projects, and once these particular commercial demonstration plants have proven to be feasible, I think you are going to find industry will be ready, willing and desirous to buy these from the Government. I feel that the Government will probably get back a large portion of their expenditures from this route.

Senator ROTH. In other words, it may not be patentable but you feel the know-how would be available—right—that industry would be glad to pay for it as they do in private enterprise to secure a process from another company?

Mr. PARTRIDGE. Right.

Senator ROTH. I believe that is all the questions I have.

FEDERAL ENERGY ADMINISTRATION

Senator RIBICOFF. I have one further question, Mr. Partridge. Tomorrow we will start hearings to set up the Federal Energy Administration. That is Mr. Simon's Agency.

Do you think FEA should have the authority to allocate authority on natural gas, rather than the Federal Power Commission, on an emergency basis to prevent shutdowns and unemployment?

Mr. PARTRIDGE. I think it has to come to that. I think these very different allocations decisions are going to have to be made by those that have a purview of all energy. They will have to know of a particular industry what their chances are of them getting coal and oil as compared to natural gas. The Federal Power Commission of course is concerned only with natural gas. I think eventually definitely an administration such as FEA is going to have to do the overall job.

Senator RIBICOFF. Thank you very much. I thank you for your contribution?

Mr. Bridges, you have finally become a prophet in your own land.

Mr. BRIDGES. That does not feel too good.

Senator RIBICOFF. All these years you have been talking and warning, to seemingly deaf ears. Everybody is now awakened to the problem and the crisis as if it just happened yesterday or today. It is very obvious from your briefing and your experience this has been in the making a long time.

It seems to me you are the man most in demand in all these hearings. I would appreciate having your testimony.

TESTIMONY OF JACK H. BRIDGES, DIRECTOR OF NATIONAL ENERGY PROGRAMS, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES, GEORGETOWN UNIVERSITY, CONSULTANT TO THE JOINT CONGRESSIONAL COMMITTEE ON ATOMIC ENERGY AND TO THE CONFERENCE BOARD

Mr. BRIDGES. I have a very short statement I would like to read, and then answer any questions that you might have.

My name is Jack Bridges. I am director of national energy programs at the Center for Strategic and International Studies, Georgetown University in Washington, D.C. I am also acting as consultant to the Joint Congressional Committee on Atomic Energy, and for the Conference Board in New York City.

I would like to make a few comments on the organization proposals that are before this committee, and on the concept itself of "Manhattan" or "Apollo" type projects as a means of helping to alleviate our national energy problems.

The proposed Federal Energy Administration should provide this country with the necessary operating entity for our short-term problems. The proposed Energy Research and Development Administration should provide this country with an appropriately focused energy research and development effort.

It is my opinion, however, that one of the most important parts is still missing. We do not have provision for a council or a man in the Office of the Presidency whose primary responsibility is to stand back from the day-to-day problems and to address our long-range energy dilemma. It is my opinion that this country is actually moving from one energy era into another. This situation poses the mandatory requirement for establishment of a long-range energy strategy designed not only to make this transition as relatively painless as possible but to maximize the opportunities that the situation presents.

I would suggest that the energy council concept of Senator Hollings, with some significant modifications, could fit this requirement.

Senator RIBICOFF. Senator Hollings and I have talked about this. I am sympathetic to what he has suggested. He thinks that we should set up a council of energy advisers in the ERDA proposal or the Federal Energy Administration.

Which would be the best vehicle in your opinion?

Mr. BRIDGES. I would set it up separately. I would use ERDA, the one you are working on today, as the organization to push the research and development concepts. The one you will be talking about tomorrow primarily is a day-to-day operation entity.

Senator RIBICOFF. I know that, but to get this done—it would be a separate title. You would put it in the White House Executive Office and it would be separate.

Which do you think would be the proper vehicle, ERDA or FEA, to make it a separate title?

Mr. BRIDGES. If you had to go that way, one or the other I would probably go to the FEA.

Senator RIBICOFF. Put it there with FEA?

Mr. BRIDGES. Yes, sir.

Senator RIBICOFF. It is an overall policy?

Mr. BRIDGES. Yes, sir. Your long-range goals, of course, would have a lot of impact on your day-to-day actions. Again, thay have to be very closely knit together.

By the same token, I would like to warn that without some sort of a long-range national energy strategy, we will probably find some of the day-to-day actions of the Federal Energy Administration and of the so-called ERDA actually compounding our problems and not solving them.

Now I would like to concentrate on the ERDA concept.

MONEY ALONE, IS NOT ENOUGH

The idea of approaching our energy problems on a massive research and development basis has considerable merit, but also offers, in my opinion, a very real danger. The danger is that the American people will be lulled into the assurance that all we have to do is appropriate massive amounts of money and then we can sit back and relax and the situation will be solved. Of course, nothing could be further from the truth. Politically, this is the easiest step to take, but unless it is accompanied by a mutitude of difficult decisions and support items, we may find that our major move into massive Government-financed research and development will be a disaster.

Let me give you some specific examples. It will do us no good to spend millions and millions of dollars on improving coal gasification techniques unless we are willing to face up to that fact that we are going to have to mine coal. The financial, political, and ecological cost factors that can burden such things as strip mining of coal could easily offset any gains that we might make with major research and development advances. Tough decisions are going to have to be made on such problems as water availability, because if they are not made, we are wasting our time talking about converting mass quantities of coal in the Western part of the country to gas or liquids. We are also going to have to face the politically distasteful situation of providing sufficient economic incentives, or we will not find the hundreds and hundreds of millions of investment dollars needed for such things as coal gasification plants.

Senator RIBICOFF. We are talking about oil shale and coal gasification.

Is it economically feasible to process oil shale and coal in locations where it is found?

Mr. BRIDGES. We may find that our production rates, particularly from shale such as coal gasification that are severely limited by water availability.

What I am trying to emphasize is, we have to start making these other decisions now. These are the decisions we have had before us for years and have not really faced.

COST PER BARREL OR KILOWATT FACTOR

The next thing we must admit is that neither the Manhattan project nor the Apollo project had a real concern about the economic efficiencies such as the "cost per barrel" or the "cost per kilowatt" that the energy research and development projects must have. We will now have to have tough cost effectiveness examinations of the capital

required for the systems we are attempting to develop, the resources that commercial systems will actually consume, and finally, the unit operating costs of such systems.

We must also remember that these new systems must be operated by employees of the utility companies, your neighborhood plumber, people who sell and service appliances, et cetera. We will not be able to accept systems that can only be operated by a few highly trained astronauts or people of that skill level.

In the legislation that you are reviewing, I would like to suggest that you assure the concept of continued civilian control over the nuclear weapons systems. This is not only desirable from the standpoint of our traditional civilian oriented decisionmaking base, but also because of our urgent need to capture for civilian use as much technological fallout as possible from military oriented research and development.

FALLOUT

Senator RIBICOFF. May I ask you at that point what do you mean by fallout?

Can you give us some examples, some fallout that we have had?

Mr. BRIDGES. Yes, sir. One of the more obvious is that of jet aircraft. An important one for the future could be laser fusion. They are being operated under a pretty high degree of security because they have a major impact on weapons systems. It also looks like with some success that the laser fusion systems may be a good way, a decade or two from now, of supplying us with large quantities of cheap energy.

Senator RIBICOFF. That has been a fallout from the military technology?

Mr. BRIDGES. Yes, sir. That is the type of thing I am referring to. I would hate to see them really getting shoved out in the corner.

Senator RIBICOFF. In other words, you feel that there has been a conflict in that testimony. You would like to see the military application staying, rather than going in the Defense Department?

Mr. BRIDGES. I would like to see it stay, especially in the future. As we go into the more technical things like nuclear fusion and even some of the more advanced solar systems, I think that we will find some of the interrelation to the sophisticated technology developed by the military systems could be very helpful.

Senator RIBICOFF. Please proceed.

Mr. BRIDGES. I realize that you cannot put too many suggested operational details into legislation, but there are two areas that I consider very important and want to make a part of the record as a suggestion for future personnel in ERDA.

GARAGE INVENTOR MUST BE SUPPORTED

First, there must be a way to keep the garage inventor heavily involved in our R. & D. efforts. By garage inventor I mean of course the independent type of inventor who over the years has been one of the major inputs into our technical systems. The Department of Commerce has done a great deal of work on the sources of our different inventions and our technical advances. A large number of the major inventions in this country have been made by the individual—in many instances individuals who have spent decades on their ideas.

Large government and tightly structured private organizations are well known for their lack of inventiveness. A concept similar to that employed by the Battelle Memorial Institute may be desirable and you might want to eventually consider funding a Comsat-type organization for the encouragement of the small inventor and the small company.

Senator RIBICOFF. Let me ask you, from your long experience in these related fields have you found a widespread practice of major companies to gain a good invention that could be used for the public interest from these garage-type inventors, and then abandoning them because for some reason or another they would not fit into the economic game plans of the major company?

Mr. BRIDGES. I have yet to find one that I could put my finger on that was a good one that has been buried. It has been picked up one place or the other and what I am talking about, things like the carburetor that gets 60 miles to the gallon for a big car. I have not found that.

If you have a really good one and you can get the patent protection, you may find that some of the larger companies do not move as fast as the inventor, or as fast as someone thinks they should. If in fact the idea is good then it will usually surface.

INCENTIVES

Finally, you are going to need to develop some way to give an incentive to the federally funded research and development contracts so that personnel involved will make major efforts to complete their work and move it into actual commercialization and use. Past history, and even current events, show that when we put large funding into Federal research and development projects we often end up literally building cities of federally financed employees and technicians. Once they are settled in their ways, have their own schools, swimming pools, country clubs, et cetera, there is a real reluctance to face the point at which the major research and development project they are working on is complete and there is no longer need for the whole organization.

Senator RIBICOFF. Do you think it would be advisable that most of this research be done in conjunction between the Federal Government and the industry, where the industry can convert their inventions and the techniques and the results of their research to actual commercial use?

Mr. BRIDGES. Yes, sir. I think we could make a major advance if we could very well insure that these major projects are carried out—there would be an incentive for all people involved, including Federal employees, to move programs into commercialization as soon as we can.

In closing, I want to express my support for ERDA and its general concepts. I think it is a long overdue move in our efforts to attack our national energy dilemma. I want to caution, however, against permitting positive moves toward establishing ERDA to lull us into relaxing other necessary efforts, especially ones that will be more politically difficult.

Senator RIBICOFF. Thank you very much, Mr. Bridges. I am not going to ask you many questions. In your short statement you have many cogent suggestions that do make a lot of sense, and I respect them because I know they come from long experience and practicality.

I hope from time to time as we go along we will have an opportunity to call on you again.

Mr. BRIDGES. Thank you very much.

Senator RIBICOFF. Mr. Bagge, please.

Thank you, sir, for your patience.

TESTIMONY OF CARL E. BAGGE, PRESIDENT, NATIONAL COAL ASSOCIATION

Mr. BAGGE. Yes, sir. I will attempt to summarize my statement. We have filed with the committee a rather extensive statement because from the point of view of the American coal industry this is a highly significant one. I will not presume on your time to read the statement except to summarize.

Senator RIBICOFF. Without objection, your entire statement will go on the record as read. I am sure that there is much of this that should be part of the permanent record. I know it will be valuable.

[The statement referred to follows:]

STATEMENT BY CARL E. BAGGE, PRESIDENT, NATIONAL COAL ASSOCIATION

My name is Carl E. Bagge. I am president of the National Coal Association, whose members include the major coal producing and coal sales companies of the nation. We welcome this forum to present testimony on a vital national issue.

Research and development is one essential key to the future of coal in the United States. It is obvious that the technological base for coal extraction, distribution, conversion, and consumption must be sound and expanding if America's energy needs are to be satisfied. It is also tragically apparent that the past neglect of research in coal is one major reason for our current technological inadequacies which compound the energy crisis.

Equally important over the long run, and perhaps more crucial in the short term, are those governmental restraints which now inhibit the coal industry's ability to produce and market its product efficiently. For example, price controls even now interfere with the rapid expansion of coal production. Air pollution regulations rule out the use of much available high-sulfur coal, coal which is sorely needed in an energy-short America and which must be mined and burned if we are to avoid an even greater crisis than we now have. Governmental policies relating to the coal leases in the West and exploration permits on western public lands have halted plans to expand the industry into some of the world's richest energy reserves.

In both the short and the long run, therefore, we need governmental policies which help coal to meet the demands of a rapidly growing and energy-intensive society. We need a soundly conceived governmental framework within which the coal delivery system—the whole complex of coal mining, transportation and use—can operate effectively and efficiently. This is necessary if we are to produce the vast quantities of coal which America will require to achieve energy self-sufficiency.

Research and development are a part of that system. But they are by their very nature lengthy processes. Pressing ahead with coal R & D now is essential—it should have started long ago. However, it will have little immediate effect in terms of added production or energy supply.

On the other hand, much can be done now in such areas as environmental control, price regulation, surface mining legislation and the tax structure to insure the orderly expansion of coal capacity so that the technologies which we are now beginning to develop at an accelerated pace will do the nation the most good.

These comments are not intended to denigrate the place of research and development. They are intended, however, to place it in proper perspective. In short, we must not become mesmerized by the potential for coal R & D and neglect the urgent need of the American coal industry to survive and to grow. Today this is the real issue—the issue which is central to our continuation as a major industrial power capable of maintaining our historic commitment to human dignity and to world peace.

It is in this context—the context of energy self-sufficiency for industrial America—that we wish to discuss the research and development needs of the coal industry over the remainder of this century.

I. THE COAL RESEARCH RECORD

The federal government has a sad record of support—or non-support—for coal research and development.

Attached as an exhibit is a listing of the funding of the Office of Coal Research for the past ten years. It is interesting to note that only in the past year or two has the OCR budget begun to reach effective levels. Prior to that time, monies allocated to OCR were so miniscule that the program of the agency could never be pursued as logic and experimental results would dictate.

There are several examples of this. In 1968, laboratory research on a promising liquefaction process developed by Hydrocarbon Research, Inc., and sponsored by OCR was completed. Proposals were developed for the construction of a pilot plant, but for lack of funds OCR had to discontinue this plant. Had it been continued it is quite probable that we would now have the technological information necessary to construct a prototype plant that could produce fuel oil from coal. This would offset the major threat posed by the cutoff of oil exports of Arab nations because of U.S. international policy.

Further, because of a lack of funds, the solvent refined coal process, now in the pilot plant stage under a contract with the Pittsburgh and Midway Coal Mining Company, remained in a state of limbo for five years. In other words, a pilot plant now under construction could have been initiated in 1966 or 1967. Again, as in the case of the H-Coal process, for lack of a few million dollars a five or six year delay was incurred.

Finally, within the past several weeks, a vessel of the U.S. Navy actually operated on a liquid fuel oil made from coal. This fuel oil was developed under an OCR contract with the FMC Corporation in a pilot plant in Princeton, New Jersey. That pilot plant was built and successfully demonstrated. However, lack of proper funding prevented bringing that plant through the demonstration phase to the point of commercial viability, and so valuable years were lost. The Bureau of Mines' coal research record reveals the same unfortunate pattern. Years of neglect were followed by a spurt of crisis spending after the passage of the Coal Mine Health and Safety Act. This desirable spending is limited: It can only be used for health and safety, and not to imporve the actual mining technology for coal, not withstanding the dramatic drop in productivity in recent years.

An expanded research and development program on mining is an absolutely necessary technology. We will discuss this in more depth later, but let us note here that had the Bureau of Mines and the Office of Coal Research been given the mandate to develop new coal mining technology, the coal industry would be much more able to respond to today's crisis by producing greater amounts of coal. Our present coal mining technology is the technology of the 1950's. It is completely unequal to the demands which we foresee in the '80's and beyond. The Congress and the American people must recognize that as we develop the technology to use coal to a much greater degree we must have a parallel technology to permit the more efficient and the safer mining of all the coal we will need.

The result of past apathy is clearly evident in our time of energy crisis. The coal industry today should be able to move to meet its greatly increased responsibilities not only to domestic consumers but also to those of our allies abroad, particularly Japan and those other nations hardest hit by the Arab oil embargo. Unfortunately, coal lacks, among other things, an adequate technological base to do so. Today at every stage of the coal system—mining, distribution, conversion, and ultimate consumption—great technological barriers impede coal growth. It is interesting to speculate what could have happened if a parallel and balanced research and development program on coal production, distribution, conversion, and consumption had been launched in 1954 when our massive national commitment to nuclear research and development was made. This is not in any way to denigrate the nuclear program. It is only to suggest that coal is one of the major reserves of energy to which we must look, a reserve with the potential to justify a research and development program on a scale comparable to the nuclear program.

Inadequate technology was tolerable in an America characterized by energy abundance. We could afford to permit our largest fossil fuel resource to stagnate in terms of technological capability. We could ignore the rewards which would flow from an expanded and successful research and development program. But we can no longer, in our present environment of scarcity—yes, of crisis—continue such a wasteful and short-sighted national policy. Nor can we in the decades ahead continue in the pattern of the past. Rather, we must now optimize all of

our remaining energy resources in order to maintain both our domestic living standards and our present and potential international commitments.

What is needed—a need that is acutely felt by the sponsors of S. 2744—is a sharp reversal of our past record of coal research and development. We must have a determined and accelerated program to provide a sound technological base for coal expansion. We must make up for the inaction of the past and more rapidly to meet the contingencies of the future.

This is a time for forging those institutions which will meet America's future energy needs. To do so we must learn from our past but more importantly, we must be prepared to forgo ingrained tradition in order to fashion those instruments which will be responsive to the future and not merely mirrors of the past. The challenges ahead will require new thinking, new institutions, and a new governmental response to the questions posed by research and development. We believe that S. 2744 is one constructive approach toward fashioning a national research and development institution capable of meeting the challenges of the 1970's and 1980's and beyond.

II. RESEARCH POLICY

The sponsors of S. 2744 have set forth a clearly defined goal for energy research and development in these words:

"The Congress hereby declares that the general welfare and the common defense and security require effective action to develop and increase the efficiency and reliability of use of all energy sources to meet the needs of present and future generations, to increase the productivity of the national economy and strengthen its position with regard to international trade, to make the nation *self-sufficient in energy* and to advance the goals of restoring, protecting and enhancing environmental quality." (Italic added)

To that we would only suggest that there should be added a time frame within which energy self-sufficiency, or at least the capability for energy self-sufficiency, should be attained.

We would also suggest two other goals which should be incorporated into the legislation. One is taken from legislation pending before the Senate. This legislation provides for a program which will:

". . . develop the technology and information base necessary to supplement development of the widest possible range or options available for future energy policy decisions by aggressively pursuing research and development programs in *a wide variety of energy technologies.*" (*italic added*)

The other goal of national policy should aim to:

". . . develop the technology to use abundant resources where possible in place of scarce resources in order to insure the optimum utilization of the totality of our resource base."

In short, we suggest as the overall goal for research and development policy the following:

"National energy research and development policy should attempt to achieve the optimum production and use of our vast coal base in an environmentally acceptable way in forms designed to maximize consumer value, extracted in the most efficient manner consistent with the health and safety of the workers involved, within the context of our free enterprise system."

Coal is an obvious choice for research and development on an expanded scale. It is our most abundant fossil fuel reserve. It is located in quantity in or near practically every part of the nation. We know how to mine it, move it, and consume it. Coal can be used in its original solid form to make heat and/or electric power. It can also be converted into liquid or gaseous forms for use in the modes most popular in today's society.

But most importantly, coal gives us an alternative to Mid-east oil. The huge reserve of coal provides us with the muscle necessary to forego the danger and the humiliation of foreign dependency and to retain our progress at home and our posture abroad. Properly developed, America's coal can become a guarantee to our allies that they need not fear the long-term threat of blackmail aimed at forcing them to adopt foreign policies not in their interest.

Thus, in providing a research and development program which will help to make the nation self-sufficient in energy, S. 2744 provides a goal for those charged with energy research and development and starts the nation toward secure energy abundance.

III. RESEARCH STRUCTURE

In attempting to analyze S. 2744 we measured it against what we consider to be the ideal research and development program. Below we have outlined conceptually what such a program should be:

As a research need is seen or anticipated, technical and economic assessments should be made of the various options to meet it. Where technical deficiencies exist, research and development should be undertaken on those options which have the best probability of success within the time frames required. Research and development resources should be allocated on the basis of the intensity of the problem and on the effort needed to develop the required technology—again within the time frames for such development. Careful control should be maintained so that the programs are directed at meaningful targets, their progress is satisfactory, and their transfer to the private sector expedited. A research concept such as this requires:

A central control agency capable of making informed, unbiased and farsighted decisions.

Sufficient support for the agency so its decisions can be translated into solid research programs.

An adequate funding level.

Close cooperation with the industries involved as well as with other governmental agencies.

This analysis leads us to support the creation of a central energy research and development administration. We believe that this administration must be a separate governmental body which includes all of the present governmental agencies involved in energy research and development. This agency could be completely independent, or it could be a part of a Department of Energy and Natural Resources, as has been suggested by the Administration. Within the research administration, however, there should be separate but equal agencies for the major sources of energy. One such agency, as suggested in S. 2744, should focus on coal, with a funding level on a parity with nuclear power. Its staff should be charged with coal development much as the current AEC is charged with nuclear progress. The head of the coal agency should report directly to the administrator of the overall energy research administration and through him to the President and the appropriate committees of the Congress.

The objective of this administration would be to carry on research and development in energy through all of the steps necessary to demonstrate commercial feasibility. Its various agencies would be both empowered to utilize in-house capabilities, such as those of the Bureau of Mines and the National Laboratories, and to contract on the outside with capable public and private research agencies.

S. 2744 is a major move in this direction. It does, in fact, establish an energy research and development administration and sets up a special section in that administration for a head of a fossil fuel research group. We suggest, however, that as the agency gets under way those programs now conducted by the present coal research agencies, i.e., the Office of Coal Research, the U.S. Bureau of Mines, and the Environmental Protection Agency, continue to function until they can be transplanted. These on-going programs are of vital interest to the coal industry in such areas as gasification, liquefaction, mining, environmental control, etc. Any hiatus in these programs or delay in their funding could be fatal to their early success.

This analysis of the ideal government agency dealing with energy research and development leads us to discuss specific provisions of S. 2744.

IV. S. 2744

In our opinion, the sponsors of S. 2744 deserve the commendation of the Congress and the American people. It provides the basic forward thrust for the type of centralized government research and development program which, properly implemented, will make possible the type of quantum jump in technology which America so sorely needs.

The basic strength of this legislation is highlighted in the first charge to the administrator of the new agency, where he is directed to exercise:

". . . central responsibility for policy planning, coordination, support, and management of research and development programs respecting all energy sources, including assessing the requirements for research and development in regard to various energy sources in relation to near term and long range needs, policy planning in regard to meeting those requirements, undertaking programs for the optimum development of the various forms of energy sources, managing such programs and disseminating information resulting thereform."

This charge makes possible a conceptual attack on America's energy research and development needs. It centralizes for the first time the R&D programs of the federal government relating to energy. It will allow available research resources to be balanced with national needs.

For too many years such centralization was missing. The various agencies of government fought for the scant available funds. Moreover no single agency could assume research and development responsibility on a national scale in order to make truly meaningful decisions.

We are particularly pleased that S. 2744 designates an assistant administrator for fossil energy. To us this means the sponsors recognize that the fossil fuel resources of the United States—most particularly the coal resource—are, and should be, on a par with nuclear energy as the twin pillars upon which energy self-sufficiency must be built. Such a parity between the fossil and the nuclear resource is long overdue.

We also believe that it is desirable policy to separate nuclear regulation from atomic energy research and development. The regulatory function of the AEC does not really belong in an agency charged with research and development. It may have been necessary in the early days of the Atomic Energy Commission when there was a need for a very close relationship between those charged with regulation and those charged with development. But, no more. We think, therefore, that the division of the two functions is extremely desirable and will do much to enhance the credibility and the effectiveness of both the Energy Research and Development Administration and the Nulcear Agency Commission.

The legislation also wisely makes the Administrator responsible for:

". . . ascertaining the existence, progress and results of other public and private research and development activities relevant to the administration's mission and correlating its own research and development programs with such public and private activities."

Obviously there is a great deal of energy R&D going on in the private sector. If it can be correlated with the public R&D, a great deal of redundancy can be avoided and maximum progress made toward the objectives of the research and development administration.

We also support the continuation of the contracting activities of the Office of Coal Research. This program has been extremely desirable in shortening the research and development lead times and bringing into government service some of America's best nongovernmental research and development institutions. We believe this activity should be continued in the new agency. In fact, it should be strengthened in order to accelerate private research and development work under government aegis and to provide for the shortest possible technology transfer time as the new technologies are developed.

We also support the transfer of the research functions of the Environmental Protection Agency to the new research and development administration. We believe this to be extremely desirable because the R&D work of EPA is obviously essential to long term energy self-sufficiency. Just as in the case of AEC, an agency cannot effectively do both regulation and research for the same industry. The temptation will always exist to declare by regulation that the Agency's research is successful.

On the other hand, there are several deficiencies in the pending legislation which we believe should be called to the attention of the committee.

First, we believe that military R&D should not be a part of ERDA. We suggest the transfer of this function to the Department of Defense or to some other agency, perhaps even the Nuclear Energy Commission. We do not in any sense suggest curtailing military R&D in energy; in fact, we believe it should be expanded if necessary. However, a governmental agency charged with civilian research and development is inherently different from an agency charged with the development of weapons and other things for use by the military. For example, a civilian R&D program must operate as openly as possible, with maximum dissemination of the information developed. On the other hand, nuclear research and development for the military must operate within an atmosphere of great secrecy and limited access to desirable information. Further, the great need for civilian R&D must permit the administrator an entirely free hand in seeking whatever funds are necessary without having to determine his priorities within the context of some overriding military need.

Moreover, we do not believe that the type of R&D carried on by the civilian agency is parallel to any great degree with the type of R&D involved in military applications.

Finally, the linking of the civilian and the military research and development programs would, we believe, have a detrimental effect on both. Of course, ERDA should cooperate fully with whatever agency handles military research and development on particular energy research programs which the military might need.

S. 2744 provides for no effective dialogue between the private and the public sector about research and development. We strongly recommend a top-level industry policy advisory committee to the agency. This committee should be made up of top executives from the various parts of the energy industry. It should also provide policy advice and industry input to the research and development program, and should develop methods for the orderly and quick transition of technology as it is developed, to the private sector. We believe that without such a mechanism, much of the work of ERDA will be misguided and, even if successful, will be transferred to the private sector more slowly than necessary.

We also strongly suggest that the advisory role of the industry committee be explicitly set forth in such a way that the administrator has to rely upon the committee as trusted advisors. He should be required to consult prior to the development of general and specific research policies as well as during the implementation phase of the programs which such policies dictate. To be truly meaningful, therefore, the advisory committee should be considered an integral part of the ERDA structure—a function which is essential to the carrying out of ERDA responsibilities.

There should also be, at least initially, some type of cooperative program between industry and government to bring into the new ERDA organization top-level scientists, engineers, and other professionals from outside the agency. This would permit the agency, especially in fossil fuel development, to receive a major forward impetus toward meeting the vastly expanded challenges which the present energy situation imposes.

Finally, we cannot leave the ERDA organization without suggesting to you the qualifications we think should be required of the people who will man the organization. These were spelled out to Representative Chet Holifield of the House of Representatives, in our letter of August 24. I would like to submit the complete text of the letter and summarize it here for the information of the committee.

We view the qualifications for top-level management of ERDA to be as follows:

First, the people should be intimately familiar with both the legislative appropriation process and with its parallels and adjuncts in the Executive Branch of government.

Second, the top-level policy makers should be able to articulate the broad policy needs and objectives of energy research in our society to government, to the research community, to the nation at large, and especially to those people who are crucial to the production and distribution and utilization of energy but are not intimately involved with research and development per se.

Third, the policymakers of the new energy organization should carry impeccable managerial backgrounds and the willingness to dedicate themselves to the future of ERDA.

Fourth, it would be desirable to bring to the new research effort top-level management with some capability in research and development projects, although we do not believe that this is an absolute necessity. It is more important, in our view, for top management to be people who possess vision, who can interact favorably with the various public and private institutions impinging on research, and who will be tough-minded in establishing research priorities and in defending them articulately in both the public and private sectors.

At the next level of ERDA, i.e., the level where the specific energy resources are dealt with, we believe that management should possess some of the following qualifications:

In coal, for example, we would recommend that the head of the coal or fossil fuel area should have the conceptual view of the coal industry as an entity. This does not mean that he must be an expert in coal research, necessarily, but rather someone who possesses a sufficient grasp on the intricacies of bringing that resource into public use that he can establish the necessary research and development priorities.

Second, we believe that he must have sufficient stature to attract professional personnel who enthusiastically and with single-minded dedication will carry out the work of the coal research function.

Finally, he must be able to sell the coal research priority in competition with all of the other priorities which will bear upon the top leadership of the federal

research and development effort. He must articulate it within the institutional structure, to Congress, to the Executive Branch, and the public at large.

V. COAL RESEARCH AND DEVELOPMENT POLICY PRIORITIES

Establishing ERDA will not, in a short time, remedy all of the shortcomings of past research and development policies. However, we can and must establish research goals, define priorities needed to achieve them, and allocate the necessary resources. S. 2744 vests this authority in the administrator. For the guidance of the committee, and hopefully for the eventual guidance of the administrator of ERDA, we suggest the following research priorities for the coal industry—priorities which are necessary to permit the maximum utilization of our vast coal resource base. The specific allocation of effort in each one will vary with time and will have to be studied when the ERDA priorities are eventually determined.

The following, however, are research priorities which we feel at this time are essential to assure the maximum contribution of the coal industry to the well-being of the American public.

Mining research

Productivity in coal mines has been in a period of substantial decline since 1969. In part, this was caused by the Coal Mine Health and Safety Act of that year, and in part, by the simple aging of coal mining technology which had remained relatively static since the 1950's. Whatever the cause, future coal demands cannot be met without a major new forward thrust in extraction technology. More importantly, health and safety are compelling forces behind research work on mining technology.

Most federal mining research is now carried out by the U.S. Bureau of Mines and is directed at health and safety problems, with no programs designed specifically to improve efficiency. We believe this health and safety research is necessary; we have urged that it be expanded. By the same token, we also urge the initiation of research programs on production technology which would, within strict health and safety requirements, improve the efficiency of coal mining.

There are obvious areas where such activities would be fruitful. Automated mining systems are sorely needed. Transport of coal from the mine face must be made truly continuous. Advance roof support and dust suppression methods would improve both safety and efficiency. More rapid tunnelling would shorten mine development time and reduce both capital and operating costs. Improved methane control, especially if done in advance of mining, would add to both safety and productivity of the coal mine. Relatively new mining systems, such as long-wall and short-wall, must be perfected and applied where safety, geology, and economics indicate. Finally, we must move to develop technology to recover deeper eastern coals and the thick underground seams of the West. It is evident that an increasing share of our future coal supplies will have to come from these two areas.

The National Coal Association has suggested the operation of several underground test coal mines. These mines would permit the testing of new or improved mining concepts without impeding current operations or subjecting research work to commercial pressures. The only real place to test mining technology is in a coal mine. The test mine permits that to be done in an environment of research, not commercial operations.

In summary, it is essential to understand that without mining technology breakthroughs it doesn't matter how many wonderful things can be done with coal. If we can't get it out of the ground, coal can never fulfill its bright potential.

Liquefaction

Producing liquid fuels from coal has been seriously neglected in the coal research programs of the past. Several promising concepts have been stalled short of pilot plant construction, one pilot plant has been shut down, and another is only now being constructed after a delay of more than five years. This is both a national and an international tragedy.

We view coal liquefaction as needed for two major reasons:

First, liquefaction processes such as solvent-refined coal, the work done at Cresap, West Virginia, and the H-Coal process, can provide a low-sulfur alternative to imported residual oil for boiler purposes. The market potential for such a product is clear when we consider the 621 million barrels of residual oil imported last year.

Second, for the longer term, coal liquefaction in conjunction with oil shale development offers the United States a clear alternative to Mid-East oil depend-

ency. While the problems connected with this alternative are not all research-oriented, we believe that a major program in this area would have beneficial results.

Pilot plant work has been going on in one liquefaction process, i.e., solvent-refined coal. Other work could be done at the existing pilot plant at Cresap. An acceleration of the liquefaction program, leading to the construction of additional pilot plants as successful research programs indicate, and the earliest possible construction of demonstration stations, would be squarely within the national interest.

The coal industry, along with many concerned citizens, has watched with alarm our growing dependency upon Mid-Eastern oil, which has grave implications for our economic well-being. Economics aside, the rapid concentration of oil supply capability in one small, unstable area of the world has frightening implications for world peace. Clearly, the dependency of the major industrial nations of the free world upon the Mid-East has introduced a chronically unsettling condition in world affairs with far-reaching policy ramifications. When the energy demands of the emerging nations of the world—which must also turn to the Middle East—are added to this demand, the problem becomes almost hopeless, as we are now seeing demonstrated around the world.

This spring I addressed this question in a paper entitled "Coal—the Energy Key to World Stability" presented to the Council for the Association for Coal in Europe at St. Ives, England. At that time I suggested a coal research conference with representatives from Western Europe and the United States to begin to develop a global coal research strategy. That suggestion was adopted by the European coal-producing nations and, as a result, the National Coal Association, with the support of the U.S. Department of the Interior, was host at such a conference last October. This international cooperative effort is an extension of our new concern to rationally develop our own—and the world's—coal reserve base.

Our vast coal resources, and to a lesser degree, our oil shale reserves, give the United States an alternative to increasing dependence on the Mid-East, both for our own use and for the free world. It is true that both technological progress and a favorable economic climate to translate that potential into actuality are needed. Fortunately, there seems to be a growing national and international consensus to do just that. I am convinced that the nation will have to decide very soon whether to become overly dependent upon fuel imports or develop the full potential of its secure coal resources.

Gasification

A major effort is already underway in coal gasification. A jointly sponsored program between the American Gas Association and the Office of Coal Research has brought new processes to the pilot plant stage. In addition, several private companies have extensive research programs of their own under way. Meanwhile, for lack of a better commercially-proven process, several natural gas pipelines are planning to construct commercial gasification plants using limited and high-cost German technology developed several years ago. This, in itself, is a sad commentary upon American technological successes in energy research.

Within the past several years there has been a new initiative in another type of coal gasification, the use of low-Btu gas in conjunction with the combined cycle to generate electrical power. This program has an exciting potential. If it is successful, future new power stations will be more efficient and will be able to burn a clean fuel made from coal. We urge full federal support of this effort and, if necessary, a crash program to make it an early success.

Power systems

Today power generation technology is obsolete. It has not changed fundamentally since Edison, for the steam cycle is still the mainstay of our electric utility industry. Tragically, power generation from either fossil fuel or nuclear power sources wastes more energy than it uses. Equally tragic, our national demand for pollution abatement has far outstripped the technological means for satisfying that demand.

Research and development in power generation is both expensive and time consuming. We cannot look for early success nor for any rapid shift from our present methods to new ones. But neither can we afford the luxury of further apathy. We must begin now to develop the power systems of the future, systems which will burn coal more efficiently and with less pollution than present power plants. We must also serve notice to the producers of electrical power that coal is and will remain a vital part of the nation's energy base for decades to come.

Several interesting research projects are already under way in the Office o Coal Research. They include fluidized bed combustion, now programmed for pilot plant operation; magnetohydrodynamics, which seems to be a longer-term project; and combined-cycle generation, to which we have already alluded. All of these new systems promise exciting prospects. All have potential, and all will be expensive to build and bring to commercial fruition.

We hope for both federal and private support in all of the projects mentioned above and in all of the others deemed advisable. Such new power systems offer a nonnuclear alternative until the more esoteric power sources, such as the breeder and fusion reactor, can be brought into the marketplace. They can span the interim period between present technology and the ultimate solution to our supply problems. Finally, if successful, these new systems give America time, measured in terms of decades, that will be needed to do the necessary research, development, and demonstration on the advanced power systems.

Environmental challenges to coal

The biggest single impediment to coal growth at present is the unattainable pollution abatement standards which have been set by the Environmental Protection Agency and the various states. Such standards have placed energy supply and environmental concern on a collision course from which can only come a national disaster. Coal is a veteran of an aspect of the energy/ecology dispute—the problem of air pollution, which became public property before the nation realized that its refined taste in fuels was an energy luxury it could not indefinitely afford. In a state of nature, coal is not a clean fuel—it carries a primeval burden of ash and sulfur and other impurities. Perhaps more would have been made of it if it had been caught young, like natural gas. Historically, the urge to improve coal has not been overwhelming.

The sure and lasting way out of this dilemma of clean air versus adequate energy is not to reject our huge reserves of higher sulfur coal, but to redeem them.

Clearly, research and development is the long term bridge between energy and the environment, a reconciliation of the heretofore unreconcilable dichotomy between these two vital national concerns. Much work has already been done to build that bridge, but a great deal more remains to be done.

The focus of attention to date has been on the problem of sulfur dioxide control technology. Several processes, both here and abroad have been brought through pilot stage and are now in various stages of demonstration work. This will require a large dollar investment and the fullest cooperation of industry and the federal and state governments involved. We hope that as the work proceeds no promising process will fail because of a lack of financial support at any stage of development. Rather, there should be support for any potentially successful SO_2 control technology until it is placed in commercial operation or it is no longer considered to be technically or economically feasible.

However, even if the problem of sulfur dioxide is solved, another combustion product, oxides of nitrogen, may loom large in the future of coal, and in fact, of all fuels. Research and development work must begin immediately and be carried forth expeditiously so that when the new standards for nitrogen oxides are designed and implemented, the technology will be available to permit coal to meet them.

It is evident that America desires both ample energy and a relatively pollution-free environment. The vast reserves of coal available to our nation can supply both, given the time necessary to do it and a research and development program which will provide the technological base for meeting our energy requirements within acceptable environmental constraints.

VI. CONCLUSION

We support the passage of S. 2744 with the suggested changes we have made. We have consistently supported the basic concepts of this legislation and with the reservations which we have set forth in this testimony we remain enthusiastic supporters. We believe that S. 2744 recognizes that the coal research program is now a matter of major national concern and deserves the close attention of those charged with the making of national policy at the highest level.

In a sense, the current imbalances in the supply and demand of energy, and the crisis which such imbalances bring to our nation, may well be a blessing in disguise. For the shock of scarcity after such a long period of abundance has forced us to focus upon the critical questions surrounding the supply and demand of energy. It has given our nation a chnace—a second chance—to put our energy house in order through sensible management and full use of its fuels inheritance. This reprieve, however, could be wasted unless the nation reverses its historical atti-

tude of something less than benign neglect toward coal. We may look ahead to the nuclear promise and to the even more remote hope of solar power. In the realistic meantime, however, we must live according to our present energy means and not draw blank checks against the future.

Research is one essential key to that future. Quite obviously the challenge of the present and the future has outstripped the capability of present governmental research organizations. Therefore, it is time to lay aside the past and to fashion the type of research and development institution capable of meeting the contingencies of the future. To do this we must move away from the biases of the past, from the narrowly construed centers of influence, as well as from tunnel-vision in the matter of energy research and development. The demands before us clearly indicate the need for conceptually viewed and implemented R&D programs in energy. Those who administer those programs must view energy as a totality and must allocate resources on the basis of the potential and need and not from the standpoint of narrow self-interest. This will also mean that the major energy resources of the future, i.e., coal and nuclear, will have aggressive, dynamic, competent research leadership, men who can develop and articulate programs which will draw maximum value from our share of the earth's bounty. S. 2744 gives us hope that the fragmented past can somehow be transformed into the unified future and that an energy research and development program truly responsive to the public need can be created, a research and development program in which all of America's energy resources can be developed according to their ability to meet the energy needs of the American people. More than this the coal industry cannot ask.

In conclusion, we pledge to you the complete cooperation of the National Coal Association and the members which it represents as you further refine and develop this legislation and as you move it through the various legislative steps and its eventual enactment into law.

National Coal Association,
Washington, D.C., August 24, 1973.

Hon. Chet Holifield,
House of Representatives,
Washington, D.C.

Dear Chet: Thank you for your letter of July 30, 1973, asking for my thoughts on the type of management capabilities which would be needed to provide the leadership for energy research and development in the years and decades which lie ahead. Certainly, in view of our current energy crisis no question is of more topical importance, and no issue bears more heavily on the future of the United States as an industrial nation.

We at the National Coal Association have obviously given this question a great deal of thought. In line with that, we are planning to testify before your Committee on the proposed reorganization of the energy function and at that time will submit further answers to several of the questions you raised in your letter. However, I would like to take this opportunity to outline briefly what I believe to be the best management structure for ERDA and what type of management capability the new ERDA should have.

TOP-LEVEL MANAGEMENT

As we view the top-level management of the new research and development effort of the Federal Government we think in terms of those who will guide its policy and will interact with the policy in government at both the executive and legislative branches at the highest level. Thus, these people should have several basic capabilities.

First, they should be intimately familiar with both the legislative appropriation process and with that process in the executive branch. As such, they should have wide experience in dealing with the leaders of Congress and with the various executive agencies which determine budget priorities and are ultimately responsible for the implementation of those priorities in the financial sense.

Second, the top-level policymakers should be able to articulate the broad policy needs and objectives of energy research in our society, both to government and the research community, along with the nation at large, and with those people who, though key in the production, distribution and utilization of energy, are not intimately involved with research and development.

Third, the policymakers of the new energy organization should carry impeccable managerial background, both in terms of past history in managing large organizations and also in the willingness to dedicate themselves to the future of ERDA. As such, we believe it to be very important for the short term, at least, to bring into

any new research and development effort a top-level management team, preferably from the private sector, who can establish the broad policy guidelines, secure the needed government and private support, and draw to it the talent at the next lower rung of responsibility who can implement a program truly responsive to the national need.

Fourth, if at all possible, it would be desirable to bring to the new research effort top-level management with some capability in research and development projects, although I would hasten to point out that I do not feel that this is an absolute necessity. It is more important, in my view, for the top management in the new federal research effort, to be people who possess vision, who can interact favorably with the various public and private institutions impinging on research, and who will be tough-minded in both the establishment of research priorities and in the articulate defense of those priorities, both in the public and the private sectors.

At the next lower level, we believe that each of the priorities for research should be headed by an individual well versed in the particular aspects of the energy segment in which he will be conducting R&D. In the coal case, for example, we believe that a top-level expert in the coal industry as an entity would be a prime prerequisite for consideration of that position. By that I do not mean an expert in one specific area of the coal research problem but, rather, someone who can view the coal resource conceptually and who possesses a sufficient grasp of the intricacies of the various aspects of bringing that resource to the public use so that he can, in fact, establish the necessary R&D priorities to do so. It is not essential that this individual have a technical background, although a technical background would be inherently desirable.

In addition, I believe that the individual must have sufficient stature that he can attract to him a body of professional personnel who will enthusiastically and with single-minded dedication, carry out the work of the coal research function of any new federal R&D program. Thus, we are, of necessity, discussing a man of high stature and recognized standing in the coal research community. Given the very complex nature of the coal research problem, the individual must possess sufficient pull to attract people from various disciplines including the technical, legal, and economic, and his stature must be such that they will, in fact, come into the program.

Finally, he must be able to "sell" the coal research priority in competition with all of the other priorities which will bear upon the top leadership of the federal research and development effort, and articulate it both within the institutional structure finally established, as well as in the Congress, the executive, and with the public at large.

As you know, the coal industry is a relatively technologically deficient industry. Erasing that deficiency is a number one challenge facing not only our industry but indeed the entire federal and industrial structure surrounding our energy industry as we move to providing America with a stable, reliable and economically secure source of fuel. An independent coal research program with a staff of aggressive, knowledgeable, and dedicated people is a vital part of that effort and we hope that in the establishment of any new energy research and development agency that the independence and proper functioning of the coal research effort will be made a clear priority both of your Committee, the Congress, and the executive.

I hope that, pending the formal hearings before your Committee, these thoughts will be of benefit to you. I shall be pleased to discuss them with you at any time you should desire.

Sincerely,

CARL E. BAGGE.

Appropriations—Office of Coal Research, U.S. Department of the Interior

	Amount
1964	$5, 075, 000
1965	6, 836, 000
1966	7, 220, 000
1967	8, 220, 000
1968	10, 980, 000
1969	13, 700, 000
1970	15, 300, 000
1971	17, 160, 000
1972	30, 650, 000
1973	44, 280, 000

Senator RIBICOFF. Please proceed.

Mr. BAGGE. We have attempted to be constructive in our summary because it is so vital to the development of the American coal industry.

May I just read a few high points?

My name is Carl E. Bagge. I am president of the National Coal Association, whose members include the major coal producing and coal sales companies in the Nation.

We welcome this forum to present testimony on a vital national issue. Research and development is one essential key to the future of coal in the United States. It is obvious, though, the technological base for coal extraction, distribution, conversion, and consumption must be sound and expanding if Americas' energy needs are to be satisfied.

It is also tragically apparent that the past neglect of research in coal is one major reason for our current technological inadequacies, which compound this energy crisis.

Equally important over the long run and perhaps more crucial in the short term are those governmental restraints which today inhibit the coal industry's ability to produce and market its product efficiently. For example, price controls even now interfere with the rapid expansion of coal production. Air pollution regulations rule out the use of much available high sulfur coal, coal which is sorely needed in an energy-short America and must be mined and burned if we are to fight an even greater crisis than we have now. Governmental policies relating to the coal leases in the West and exploration permits on western public lands have completely halted plans to expand the industry into some of the world's richest energy preserves.

I might say with all due respect, the Senate enacted surface mining legislation which actually prohibits the production of coal through surface mining in the States of Wyoming, Montana, and the Dakotas. The implications of that in terms of growth and development of the American coal industry are most profound in both the short and long run.

NEED FOR GOVERNMENTAL POLICIES TO MEET COAL DEMANDS

Therefore, we need governmental policies which help coal to meet the demands of a rapidly growing and energy intensive society. We need a soundly conceived governmental framework within which the coal delivery system, the whole complex of coal mining, transportation, and use, can operate effectively and efficiently.

This is not true today. This is necessary if we are to produce the vast quantities of coal which America will require to achieve our energy self-sufficiency.

Senator RIBICOFF. What page are you reading from now?

Mr. BAGGE. Page 2.

The point that I am trying to make is that coal research is but a subsystem in the total coal delivery system. Even if, for example, we had the technology today to convert coal into the whole spectrum of liquid fuel, home heating oil, petroleum, low Btu gas, the total coal delivery system—which includes production—and the logistics of our industry are in such a position that this industry simply could not deliver today. So all we are suggesting as the Senate focuses on R. & D. is that you recognize that R. & D. is one subsystem of the total coal delivery system. Mr. Chairman, I think the American public and,

indeed, some of our opinionmakers, have become mesmerized with the new ideas and the rediscovery of the coal industry, conversion and liquefication. Our concern is that we are forgetting that this industry, which comprises 4,000 highly fragmented, institutional entities—which today are marginal at best, economically—is simply not in a position with the current production technology to deliver with that coal delivery system the 1½ billion and even the 2½ billion tons that we were told we are being called upon to deliver.

Senator RIBICOFF. How do you think we should activate the capacity of these 4,000 units to make this delivery?

Do you find that capital structure of this country or the world interested or available, or do you believe that the subsidy of Government loans is needed, or what do you believe is necessary to get these units deliverying coal for the American people?

GRIEVANCES AGAINST EXISTING GOVERNMENTAL POLICIES

Mr. BAGGE. To respond to your questions, I would have to give you a whole list of grievances we have against existing governmental policies.

Senator RIBICOFF. All right.

Mr. BAGGE. The foremost of that is that under the existing price restraints, there are absolutely no incentives, there is no possibility for any one of those 4,000 economic entities to go to a bank to secure the capital that is required to open a new mine, for example. There are uncertainties which permeate the total coal delivery system at the production, and at the delivery and, at the consumption end. Our air quality regulations have wiped out virtually all of the coal east of the Mississippi, the surface mining legislation has created such uncertainties with the Senate of the United States, and the House—not the subcommittees of the House—now saying it is a matter of national policy. We are going to force energy underground at a time when there is no way we can mine the quantities of coal that are essential underground.

With the whole range of problems that have provided us with such uncertainties, we cannot simply go to the capital markets to open mines, let alone new deep mines. There is no incentive to open up a surface mine today when it is a matter of national policy, that we are going to phase out half of the total production capacity of this Nation which is mined by surface mining.

Senator RIBICOFF. In the setting up of the FEA tomorrow, on which we will have testimony, the Cost of Living Council—excuse me. May I have your indulgence by going to vote and then I will come back?

Mr. BAGGE. Yes, sir.

[A brief recess was taken.]

Senator RIBICOFF. Thank you, Mr. Bagge. You have been around here long enough to know the meaning of the bells.

You may proceed, sir.

Mr. BAGGE. Thank you.

I think I was responding, Senator, to your question about what it would take to transform this industry of 4,000 economic entities. I think I ticked off some of our problems. I would like to respond to your later question, which was to the effect that with the establish-

ment of the new Federal Energy Administration, they will bring together in that agency the levers of power with respect to the Cost of Living Council so they could be mobilized in the public interest. This is a very progressive and forward step.

SHORTAGE OF BOLTS CLOSES COAL MINES

Our problem has not only been with communicating our concerns to those persons associated with energy development but in making them in turn make Dr. Dunlop of the Cost of Living Council concerned. This is not only to achieve some modicum of profitability, but to seek the necessary supplies of the whole range of materials that we have experienced shortages in. Roof bolts, for example. We were advised 20 days ago that the steel industry was given a relief with respect to that area so they could produce the rods to produce the roof bolts. We have been shutting mines down in the Nation today because of the shortage of the roof bolts. This is tragic.

I certainly welcome the establishment of the FEA and look forward to the hearings which you will be sharing tomorrow and the next day, as I understand it, to attempt to put these levers of power together in such a way that these decisions can be made quickly and decisively.

GRIEVANCE AND REDRESS PROVISION IN FEA

Senator Ribicoff. There is also a provision in the FEA to take care of bottlenecks so you will not be in this tragic position of denying you fuel to run your mines for productive purposes.

Mr. Bagge. We have had that problem in the last 60 days. We are now experiencing a whole range of other commodities, the bolts that operate from the mine face.

Senator Ribicoff. I am wondering, Mr. Bagge, since I have your statement, I have read it; it is going into the record; I do not know when I am going to have to run for another vote. If I could now ask you some questions that I have to make the record a lot more complete, because what you say is in the record.

Mr. Bagge. I would be delighted.

Senator Ribicoff. As we consider this bill, one of the basic issues is the Federal role in solving the energy crisis.

What do you think the Government should do, what should private enterprise do, what is the proper division of responsibility?

INVOLVEMENT OF PRIVATE INDUSTRY

Mr. Bagge. In our statement we say first of all, the bill does not provide as it is presently drafted, for a consultative or advisory role from the private sector. The bill itself should provide statutorily and mandatorily for an input, a continuing dialog with ERDA and the private sector.

Senator Ribicoff. You think that there should be an advisory group from each segment of the energy field.

Mr. Bagge. I think this is a critical omission, with all due respect to the drafters of the bill. I think this is a critical omission because if we do not have that kind of a continuing dialog from the private sector relating the real world problems to the ERDA Administrator or As-

sistant Administrators, this may—I say may, respectfully—be too blue-skyed. We are not going to be coming to grips with the real world problems we have to face. They may be prosaic problems, but they are critical problems.

I speak here specifically for the coal industry. One of the things, Senator, that we tried to make the administration aware of is the problem we have with respect to mining technology. I say with all due respect that I do not think that most of the people who are concerned with energy R. & D. development, the Department of Interior, the Office of Coal Research, has not been working in mining technology. We have a very primitive mining technology in the coal mining industry today. It is an obsolete technology. It is only mechanized to the pick and shovel.

If we are going to achieve the levels of production that we have to achieve, we have to make major breakthroughs in mining technology, however prosaic that may be regarded by people who think in terms of conversion technology and other esoteric things.

REPORT GIVES COAL MINING TOP PRIORITY

I was delighted to see in Chairman Ray's report to the President, which was submitted and made public yesterday, that there was indeed objection in the ordering of priorities. Chairman Ray did, in dealing with coal, put coal mining technology as a top priority.

Senator Ribicoff. Having read that, do you approve of Chairman Ray's recommendation as it affects coal?

Mr. Bagge. The kind of monetary commitment has to be regarded as minimal. I am delighted, having survived the kind of budget we have in the Office of Coal Research. I took the liberty, Mr. Chairman, of including in my statement—just to provide the committee with an insight as to the kind of level of funding we have had in the past—the figures from 1964 to 1973 on the funding for the Office of Coal Research of the Department of Interior. This has been so minuscule in view of the nature and scope of the problem that we can only be delighted that we are now being recognized as a primary fuel for the Nation.

We have been relegated, as you know, with the nuclear promise in the decade of the 1950's as being an industry that was going to be phased out. In Europe they used the term they were going to rationize the coal industry. I might say in response to the question of the previous witness, we are delighted that we are creating the institutional apparatus today to join the western European coal producers and ourselves and Canada in an institutional attempt in the private sector, wholly apart from government, by the establishment of an international Coal Research Commission to avoid redundancy, to jointly fund and to pool the kind of technical expertise such as it is in the coal industries of the free world to provide an alternative to Middle Eastern oil.

Senator Ribicoff. One of the great issues facing the Nation is the balancing of our need for energy to operate the economy and our need for a healthy environment. Your statement is critical of present environmental standards.

Can we produce the necessary coal without damaging the environment?

ENVIRONMENTAL TRADEOFFS

Mr. BAGGE. When you say damaging the environment, Senator, I have to respond in order to be more precise, by saying we have to make environmental tradeoffs. In the field of air pollution, for example, we cannot set standards that simply cannot be met and result in economic dislocation as it has by wiping out 80 percent of the entire coal resource base east of the Mississippi. We cannot enact a strip mining law with the Mansfield amendment which wipes out as a matter of national policy, the entire resource base of the coal industry west of the Mississippi.

If that is impacting on the environment, so be it. We have to surface mine for coal. We have to enact laws that attempt to regulate reclamation and not abolish surface mining as a matter of national policy. We have to create environmental standards in a timeframe that are realistic, and can be realistically achieved in the real world.

I submit respectfully that I think EPA was irresponsible in 1971 when it accepted the State implementation plans where in the very finding that was made by the Administrator of EPA at that time, he specifically said that these State implementation plans could not be achieved. Notwithstanding his own finding of that order, the Administrator of EPA at that time went ahead and implemented a State plan.

I can only characterize that, with all due respect, as an irresponsible act of the Government.

Senator RIBICOFF. Let me ask you. It is obvious for the next few years that there will be no great increase in the amount of domestically produced energy, so we are going to have to concentrate on conservation measures to reduce our demand for energy.

Are there measures that you could recommend that would cut the demand in the use of coal?

Mr. BAGGE. I cannot think of any. When you talk about conservation, Mr. Chairman, and this may be a biased viewpoint, we regard the increased production and utilization of coal and its substitution for use in utilities throughout the Nation, in industrial plants throughout the Nation, freeing up the flaring of gas, the flaring of oil, as indeed the most single decisive conservation measure that can be taken in terms.

Senator RIBICOFF. I know that, but are there methods that are being used where coal is wasted? Not substitutes. I understand there would be more coal.

Is there any waste, basically large scale waste of coal anywhere in the country?

Mr. BAGGE. I cannot think of any, Senator.

Senator RIBICOFF. You do not know of any?

GENERATING EFFICIENCY

Mr. BAGGE. I will say this in response to that question. We could put ERDA to work on the generation and efficiency to enhance, from the existing 35 percent generating efficiency where we waste in the production of electric power 65 percent of our basic fuels, whatever it is, coal, oil or gas. If we could just make an incremental breakthrough in the generating efficiency of our electric generating industry, that I

think would be the largest single contribution to the conservation that can be made.

Senator RIBICOFF. Are there methods to diminish this waste in generating electricity that electric companies do not use, or are there no methods?

Mr. BAGGE. There are technologies, Mr. Chairman, which are being studied, which would achieve this. A combined cycle, for example, in my prepared text I cite specifically some of the technologies which have not been funded at any kind of realistic levels that are designed to enhance generating fuels. We are working now with the Russians. In a major way, we have done far more work in this specific area where you eliminate the moving parts, and where you transform coal directly through MHT, the MHT process.

There are other processes. This would be at the top of the order of priorities for ERDA. These are things that are of the future that require research on a scale such as envisioned by this legislation.

Senator RIBICOFF. One question concerning ERDA.

How far down the road concerning production should it go?

Should ERDA merely demonstrate technological feasibility, or should it go further and demonstrate commercial feasibility?

Mr. BAGGE. If it demonstrates technical feasibility, it seems to me the private sector will pick it up and demonstrate its commercial feasibility.

Senator RIBICOFF. Once they have the technical competence you are willing to take whatever risks there are commercially?

Mr. BAGGE. When you say "we," the coal industry, the kind of risk that we would take is in the mining sector. I do not see our industry as participating in the massive conversion plants which require capital funds that exceed our ability to capitalize. The electric utility industry, the gas industry, which would be principally involved in transforming our product into their product, I think would be involved in that.

Certainly, in the area of mining technology, if the supposed laser technology could be employed or gassification, or if these kinds of technologies could be demonstrated, it is certainly to our interest as an industry to move in and make those commercially feasible. That would be our role, provided we, as I say, have an ongoing dialog with an advisory group that is aware on a continuing basis at least as these technologies progress, what the progress is.

This is basic. This is not in the legislation at the present time.

Senator RIBICOFF. How much in the coal industry in its entirety is spent?

Do you spend much?

NATIONAL COAL ASSOCIATION R. & D.

Mr. BAGGE. We are making a survey right now. We do not label, our industry does not label the great deal of research that we do as research. We do not have sophisticated research laboratories. The National Coal Association funds one. We have one other major coal company that has a laboratory. Our industry has not been either institutionally or financially capable of sustaining any massive or even significant research capability. We do however do a great deal

on the developmental side, R. & D. research and development. We do not label it research or development, but it is.

We are now making a survey because of questions like I got from the chairman of the House Committee in response to my testimony on his very bill, to make a survey to determine precisely what the figure is. I have had to advise our membership, even though the, are not used to thinking in terms of research, that the kind of development work which they do with the manufacturers of mining equipment and machinery is indeed developmental work which does not pay out in increased productivity, but does pay out in terms of developing a new product.

Senator RIBICOFF. Is there any fear on the coal industry's part that nuclear energy will dominate this new agency?

Mr. BAGGE. There is that fear based on what has happened in the past when we were totally ignored, Mr. Chairman. I think the provision calling expressly in the statute for an Assistant Administrator for fossil fuel development provides a great deal of comfort for the coal industry when we are given institutionally within the new apparatus a mission; that is, specifically to design and develop coal technology and develop mining research.

I would like to say in that connection, Mr. Chairman, I think this is equally important as our plea that the committee give consideration to an advisory committee of people from the private sector working with ERDA on a continuing basis, that the mining research functions be transferred to ERDA as well. When you deal with coal, it must be remembered, we have an obsolete mining technology. ERDA must address itself to the mining technology as well as to gasification and liquefaction. Even if they develop gasification and liquefaction on a commercial basis, if the American coal industry has not got the mining capability to sustain the levels that are required by these new technologies, these will all be for nought.

Senator RIBICOFF. That is contemplated.

NEW TECHNOLOGY

Do you know now of any technology in existence which would be helpful in preventing damage to the environment of the mining operation?

Mr. BAGGE. New technology?

Senator RIBICOFF. New technology.

Mr. BAGGE. I can think of a number of techniques that are employed—long wall mining, short wall mining instead of the roof and pillar system where we had problems of the depression of the land in underground mining. We have not done a great deal in terms of this except by a few companies on their own, and except in terms of surface mining reclamation.

Our concern lies in the fact, as the bill is presently directed it provides only for the transfer from the Bureau of Mines to ERDA of the Energy Research Center. What I am suggesting is that the bill should expressly provide for transferring from the Bureau of Mines those research related efforts that deal with mining technology. That is not privided for in the bill right now, Mr. Chairman. We think that it is urgent that mining technology be treated with ERDA with the

kind of funding that they will have, and be given the kind of consideration which it has never had before.

Senator RIBICOFF. Let me ask you how many people are now engaged in the mining of coal?

Mr. BAGGE. Something like 200,000 mining.

Senator RIBICOFF. 200,000?

Mr. BAGGE. The total industry investment is $4 million.

Senator RIBICOFF. Are there enough miners in this country to take care of the expanded mining of coal?

Mr. BAGGE. If the direction of the national policy is in forcing the American coal industry underground, the answer is "No"; because that would require highly trained, highly skilled men to work underground. If instead we are going to regulate surface mining instead of eliminating surface mining, the answer is "Yes."

Senator RIBICOFF. Is there difficulty of regulating surface mines so you can have reclamation, restoration of the land, not just scar tissues and piles of rubble?

Mr. BAGGE. I see no inherent difficulty, Senator. But I respectfully submit that the Senate enacted bill and the House Subcommittee's Mining and Environment recommended bills which are going to the full committee on January 27 are totally inconsistent with the achievement of our national goal and effective reclamation.

Senator RIBICOFF. Thank you very much, Mr. Bagge. I appreciate your patience. I cannot apologize for the interruptions because I had no control over them. Thank you very much for your valuable and expert testimony. I am most appreciative.

Mr. BAGGE. Thank you very much.

Senator RIBICOFF. The committee will stand adjourned until further call by the Chair.

[Whereupon, at 3:45 p.m., the subcommittee adjourned, subject to the call of the Chair.]

TO ESTABLISH AN ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION AND A NUCLEAR ENERGY COMMISSION

MONDAY, DECEMBER 10, 1973

U.S. SENATE,
SUBCOMMITTEE ON REORGANIZATION, RESEARCH,
AND INTERNATIONAL ORGANIZATION,
COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 10 a.m., in room 3302, Dirksen Senate Office Building, Senator Abraham Ribicoff (chairman of the subcommittee) presiding.

Present: Senators Ribicoff and Percy.

Also present: Paul Leventhal, special counsel, and Susan S. Geoghegan, chief clerk.

Senator RIBICOFF. The committee will be in order.

Our first witness today is Mr. James T. Ramey, the former Commissioner of the Atomic Energy Commission.

Mr. Ramey, you may proceed as you will, sir.

TESTIMONY OF JAMES T. RAMEY, FORMER COMMISSIONER OF THE ATOMIC ENERGY COMMISSION

Mr. RAMEY. Thank you very much, Mr. Chairman. I am pleased to respond to your invitation to comment upon S. 2744, a bill to reorganize the energy research and development agencies of the Federal Government.

I support the favorable consideration and enactment of S. 2744 as the most practicable means of consolidating and expanding the fragmented energy research and development programs and agencies in the Federal Government. It should be recognized of course that additional changes in the structure of the proposed Energy Research and Development Administration, ERDA, will evolve as experience is gained. The concerns that I bring out, and the changes that I suggest, are mainly directed to these future contingencies, although if there is a delay in the enactment of S. 2744, some of them could appropriately be taken into account in marking up this bill.

By way of background——

Senator RIBICOFF. If you would like to summarize your statement, your entire statement will go into the record as read.

[The prepared statement of Mr. Ramey follows:]

STATEMENT BY JAMES T. RAMEY, FORMER AEC COMMISSIONER

Mr. Chairman and members of the Committee, I am pleased to respond to your invitation to comment upon S. 2744, a bill to reorganize the energy research and development agencies of the Federal Government.

I support the favorable consideration and enactment of S. 2744 as the most practicable means of consolidating and expanding the fragmented energy research and development programs and agencies in the Federal Government. It should be recognized of course that additional changes in the structure of the proposed Energy Research and Development Administration (ERDA) will evolve as experience is gained. The concerns that I bring out, and the changes that I suggest, are mainly directed to these future contingencies, although if there is a delay in the enactment of S. 2744, some of them could appropriately be taken into account in marking up this bill.

By way of background, I have had a long and continuous interest in the subject of energy beginning with my work in the Tennessee Valley Authority (TVA) in the early and mid 1940's. I had a hand in the drafting of the Atomic Energy Act of 1946, and my interest in energy has broadened over the years in which I was an Assistant General Counsel of AEC in the early days of the development of nuclear power (1947–56), as Staff Director of the Joint Congressional Committee on Atomic Energy (1956–62) and for almost eleven years as an AEC Commissioner (1962–July 1973). Now I am back as a Consultant to the Joint Committee on Atomic Energy.

My involvement in energy studies goes back to the Joint Committee studies on energy in the late 50's, the AEC Report to President Kennedy in 1962, serving as AEC's Representative on the Interdepartmental Study on Energy R & D & National Progress (the "Cambel" Report) in the mid 60's as well as having had much to do with the establishment and activities of the inter-agency Power Plant Siting Group which Dave Freeman headed up for the Office of Science and Technology in the late 60's. More recently, until my term expired on July 1, 1973, I served as the lead Commissioner in AEC in connection with atomic power development, and particularly in connection with the breeder demonstration project.

My statement today is the first I have given before the Senate Government Operations Committee since I provided my dissenting views in a hearing on August 5, 1971 in regard to S. 1431, a bill to establish a Department of Natural Resources. I am pleased that S. 2744 provides for an independent agency to consolidate all energy R & D—not dissimilar from my recommendation in 1971.

The Congress and the Administration are wisely taking a successful, independent, going R & D organization (ACE) and restructuring and supplementing it as a new consolidated R & D administration. This is much better than placing it under the enervating structure of a reconstituted Cabinet Department. I also believe the timing is about right, particularly in terms of workload, to provide for a separate regulatory organization in the Nuclear Energy Commission (NEC).

PLANNING AND ESTABLISHING PRIORITIES

In my opinion, the provisions of S. 2744 and related explanatory statements provided a clearer and more substantial role for ERDA to assess the needs for energy R & D, public and private, and to provide the overall planning of R & D energy programs.

As I see it, ERDA in carrying out its R & D assessment and planning role would of course consult with and obtain data from the Interior Department as to Interior's resource assessment and inventories. But ERDA would have to have some capability to judge the adequacy of Interior's (or DENR's) resource assessments.

ERDA would have even more relationships with the newly established Federal Energy Administration. And of course the Director of the FEA, as the President's principal energy advisor, would provide overall policy guidance to ERDA in the R & D field.

Perhaps the best vehicle for maintaining the proper relationships between ERDA and the Interior Department, the new FEA, and other agencies interested in energy would be to establish a Federal Energy Council. Such a council would be composed of top representatives of FEA, ERDA, Interior, EPA, FPC, and NEC, with the Director of the new FEA serving as Chairman.

Such a Federal Energy Council, among other things, could provide advice to ERDA on energy R & D needs and priorities. Of course the OMB would still be omnipresent in reviewing ERDA budgets, but hopefully the Presidential and Congressional commitment as to objectives and funding would hold OMB in check. In this connection, consideration should be given to giving ERDA authority to make project commitments with multi-year funding of expenditures.

CONTINUANCE OF CAREER MERIT SYSTEM FOR ERDA OPERATIONS

In establishing ERDA, using the AEC organization in part as a basis, it is important that the AEC career merit system of personnel be continued. It is little talked about or understood that one of the most important reasons for AEC success in the development of nuclear electric power plants, and in its other R & D and regulatory activities, is that AEC has been essentially non-political. This has been true in regard to its personnel selection below the Commissioner level, and by its contractor operated laboratories and installations.

I believe it is important that the legislative history of S. 2744 recognize the Congressional intent that personnel of ERDA under section 107(a) of S. 2744 be placed and kept under AEC's career merit system. Chairman Ray of AEC testified that this was the Administration's intent.

In connection with ERDA's career system S. 2744 includes several significant organizational changes from the ERDA organization provided for in the predecessor bill S. 2135. S. 2135 provided for a Presidentially appointed-Senate confirmed Administrator and Deputy Administrator. In addition, Mr. Ash of the OMB testified that there would be a career, Executive Level III Associate Administrator. This career position has been dropped in S. 2744.

S. 2135 also contemplated that there would be five career Assistant Administrators in charge of respectively, Fossil energy; nuclear energy; research and advanced energy systems; environment, safety and conservation; and national security. In lieu of these five key career positions, S. 2744 provides for five Assistant Administrators to be appointed by the President and confirmed by the Senate.

The net effect of these proposed organizational changes is to replace key career scientists and administrators as contemplated in S. 2135, and in the current organizational arrangement of the Atomic Energy Commission, with political appointees. I question seriously that such a change will enhance the capability of ERDA to effectively manage the broad research and development charter which the bill would give to it.

The requirement of White House appointment of Assistant Administrators would make it difficult to recruit and hold on a continuing basis the highly qualified scientific and technical administrators needed for successful R & D programs. The experience of the Interior Department in early 1973, when its total energy leadership at the Assistant Secretary level was summarily decimated, is an example of the short-termer syndrome of political appointees.

PROBLEM OF GENERAL MANAGEMENT IN ERDA

A further problem under S. 2744 is the lack of provision for a career official whose function is the general management of ERDA. The statutory establishment of strong Assistant Administrators in programmatic fields whose projects in many cases will be carried out by multi-program laboratories and installations will pose many complex management problems requiring close coordination and direction. I doubt very much whether the Director or the Deputy Director can have the time to provide the continuing on-going administrative coordination and direction required at the general management level.

Indeed, the political appointment of the Assistant Directors and the lack of means of overall general management at ERDA will tend to create the type of bureaucratic "fiefdoms" in R & D which the consolidation in ERDA was supposed to eliminate.

I can testify from many years of close association with the Atomic Energy Commission that the career management and scientific personnel of AEC (including the General Manager, Deputy General Manager and Assistant General Managers provided for by the Atomic Energy Act) have been a very important factor in the successful management of AEC's programs.

I believe this Committee should seriously consider adding to S. 2744 provision for a career Associate Administrator and at some time changing the five Presidentially appointed Assistant Administrators to career positions. I recognize that there are special problems in regard to establishing and preserving the functions of the Assistant Director for fossil energy development. Language could be added to the bill which would adequately preserve the role of the Assistant Director.

I have been requested by the staff of the subcommittee to comment on the question of whether AEC's weapons development and manufacturing programs should be transferred to ERDA as provided in S. 2744. In my opinion, these programs should be under the ERDA organization. The principal reason for this is because the three principal AEC weapons laboratories—Los Alamos, Livermore and Sandia—all have important peacetime R & D functions, particularly in the

energy field. Various projects such as laser-fusion development have both weapons and civilian applications.

In view of the above, it would be difficult for these laboratories to conduct R & D work for both ERDA and say, the Defense Department. It would not be as difficult for AEC weapons manufacturing activities to be transferred to DOD since they are conducted at different contractor facilities. However, there are many interrelations even here in the weapons complex which being under one management umbrella would facilitate.

BOARD VERSUS SINGLE ADMINISTRATOR FORM OF ORGANIZATION

A further question raised by your staff requests my comments as to whether ERDA might appropriately be headed by a Board composed of three members, such as TVA.

Although the single Administrator form can be workable, there could be several advantages to a full-time Board appointed by the President with the advise and consent of the Senate:

1. A Board would provide for a broader background of interests than a single Administrator. Thus, for example, one board member might have a fossil fuel background, the other board member might have a nuclear or advanced R & D background, and the chairman might appropriately have an engineering or management background not directly from the energy field.
2. Such a three-member board, with Senate confirmation, would help insure that ERDA was not dominated by a single Administrator, from say the oil, nuclear, or other fields of energy.
3. A three-member board would also assure better access to information by the appropriate congressional committees.
4. A three-member, full-time board would facilitate establishing a career Administrator or General Manager to provide the overall general management for the agency. The need for this career function was discussed previously.
5. The three-member board system would also facilitate establishing the Assistant Administrators as career positions. This would help in avoiding insulated bureaucracies headed up by political hacks which has occurred in various cabinet departments and single administrator agencies.
6. Lastly, a Board would facilitate overall review of the many programs of ERDA, including the weapons development program. Thus, each board member could follow several programs of interest, such as occurs in AEC.

The single administrator concept which has been the pet idea of the OMB and its predecessors the Bureau of the Budget is supposed to provide faster and more efficient decision-making than a multi-headed agency. However, TVA and AEC experience, as well as experience in private industry, shows that the commission form of management of large enterprises can be successful.

RELATIONS BETWEEN ERDA AND THE NUCLEAR ENERGY COMMISSION

One of the most difficult problems in separating off the AEC regulatory organization as NEC will be for NEC to maintain close communication and liaison with the ongoing ERDA R & D programs, particularly those in the field of safety. Even under the present AEC umbrella, this has been a difficult task.

When NEC is established, there will be a tendency for it to wish to conduct its own R & D on safety beyond the narrow confines of confirmatory research. Unfortunately NEC as a regulatory organization is not and cannot be adequately staffed to conduct good R & D.

Undoubtedly in a few years NEC could settle down into a routine regulatory agency and gradually get squeezed in terms of funding and staff. Thus, NEC could follow the fate of most regulatory agencies and end up industry-dominated. Various means of preventing this possibility, through close technical collaboration with ERDA, will probably be required.

Finally, I would point out two items of unfinished business which should be kept in mind for future action in relation to ERDA.

1. The need for multi-year funding for ERDA projects.
2. The transfer of other energy related R & D programs to ERDA. An example is the desalting R & D program presently conducted by the Office of Saline Water of the Interior Department. This program, which offers great potential in combination with nuclear power plants, has been cut back severely by the OMB.

In conclusion, Mr. Chairman, let me repeat that I fully support the enactment of S. 2744. I hope my comments today may lead to some improvements in the bill or in its administration.

That concludes my testimony, Mr. Chairman.

Mr. RAMEY. My statement today is the first I have given before the Senate Government Operations Committee since I provided my dissenting views in a hearing on August 5, 1971, in regard to S. 1431, a bill to establish a Department of Natural Resources. I am pleased that S. 2744 provides for an independent agency to consolidate all energy R. & D.—not dissimilar from my recommendation in 1971.

The Congress and the administration are wisely taking a successful, independent, going R. & D. organization (AEC) and restructuring and supplementing it as a new consolidated R. & D. administration. This is much better than placing it under the enervating structure of a reconstituted Cabinet department. I also believe the timing is about right, particularly in terms of workload, to provide for a separate regulatory organization in the Nuclear Energy Commission, NEC.

PLANNING AND ESTABLISHING PRIORITIES

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As I see it, ERDA in carrying out its R. & D. assessment and planning role would of course consult with and obtain data from the Interior Department as to Interior's resource assessment and inventories. But ERDA would have to have some capability to judge the adequacy of Interior's, or DENR's resource assessments.

ERDA would have even more relationships with the newly established Federal Energy Administration. And of course the Director of the FEA, as the President's principal energy adviser, would provide overall policy guidance to ERDA in the R. & D. field.

Perhaps the best vehicle for maintaining the proper relationships between ERDA and the Interior Department, the new FEA, and other agencies interested in energy would be to establish a Federal Energy Council. Such a council would be composed of top representatives of FEA, ERDA, Interior, EPA, FPC, and NEC, with the Director of the new FEA serving as Chairman.

Such a Federal Energy Council, among other things, could provide advice to ERDA on energy R. & D. needs and priorities, which I understand your committee is interested in. Of course, the OMB would still be omnipresent in reviewing ERDA budgets, but hopefully the Presidential and congressional commitment as to objectives and funding would hold OMB in check. In this connection, consideration should be given to giving ERDA authority to make project commitments with multiyear funding of expenditures.

THE CONTINUANCE OF CAREER MERIT SYSTEM FOR ERDA OPERATIONS

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In connection with ERDA's career system, S. 2744 includes several significant organizational changes from the ERDA organization provided for in the predecessor bill S. 2135. S. 2135 provided for a presidentially appointed, Senate confirmed Administrator and Deputy Administrator. In addition, Mr. Ash of the OMB testified that there would be a career, Executive Level III Associate Administrator. This career position has been dropped in S. 2744. I think its purpose was originally to be a kind of general manager.

S. 2135 also contemplated that there would be five career Assistant Administrators in charge of respectively: fossil energy; nuclear energy; research and advanced energy systems; environment; safety and conservation; and national security. In lieu of these five key career positions, S. 2744 provides for five Assistant Administrators to be appointed by the President and confirmed by the Senate.

The net effect of these proposed organizational changes is to replace key career scientists and administrators as contemplated in S. 2135, and in the current organizational arrangement of the Atomic Energy Commission, with political appointees, I question seriously that such a change will enhance the capability of ERDA to effectively manage the broad research and development charter which the bill would give to it.

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Indeed, the political appointment of the assistant directors and the lack of means of overall general management at ERDA will tend to create the type of bureaucratic "fiefdoms" in R. & D. which the consolidation in ERDA was supposed to eliminate.

I can testify from many years of close association with the Atomic Energy Commission that the career management and scientific personnel of AEC, including the general manager, deputy general manager, and assistant general managers provided for by the Atomic Energy

Act, have been a very important factor in the successful management of AEC's programs.

I believe this committee should seriously consider adding to S. 2744 provision for a career Associate Administrator at career level IV, which would be the same as the present Assistant Administrator, and at some time changing the five Presidentially appointed Assistant Administrators to career positions. I recognize that there are special problems in regard to establishing and preserving the functions of the Assistant Director for fossil energy development. Language could be added to the bill which would adequately preserve the role of the Assistant Director.

WEAPONS DEVELOPMENT

I have been requested by the staff of the subcommittee to comment on the question of whether AEC's weapons development and manufacturing programs should be transferred to ERDA as provided in S. 2744. In my opinion, these programs should be under the ERDA organization. The principal reason for this is because the three principal AEC weapons laboratories—Los Alamos, Livermore, and Sandia—all have important peacetime R. & D. functions, particularly in the energy field. Various projects such as laser fusion development have both weapons and civilian applications.

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ADMINISTRATOR VERSUS THREE MEMBER BOARD

A further question raised by your staff requests my comments as to whether ERDA might appropriately be headed by a board composed of three members, such as TVA.

Although the single administrator form can be workable, there could be several advantages to a full-time board appointed by the President with the advice and consent of the Senate:

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2. Such a three member board, with Senate confirmation, would help insure that ERDA was not dominated by a single Administrator, from say the oil, nuclear, or other fields of energy.

3. A three-member board would also assure better access to information by the appropriate congressional committees.

4. A three-member full-time board would facilitate establishing a career Administrator or general manager to provide the overall general management for the agency. The need for this career function was discussed previously.

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5. The three-member board system would also facilitate establishing the Assistant Administrators as career positions. This would help in avoiding insulated bureaucracies headed up by political hacks which has occurred in various cabinet departments and single-administrator agencies.

6. Lastly, a board would facilitate overall review of the many programs of ERDA, including the weapons development program. Thus, each board member could follow several programs of interest, such as occurs in AEC.

The single-administrator concept which has been the pet idea of the OMB and its predecessors, the Bureau of the Budget, is supposed to provide faster and more efficient decisionmaking than a multiheaded agency. However, TVA and AEC experience, as well as experience in private industry, shows that the Commission form of management of large enterprises can be successful.

One of the most difficult problems in separating off the AEC regulatory organization as NEC will be for NEC to maintain close communication and liaison with the ongoing ERDA R. & D. programs, particularly those in the field of safety. Even under the present AEC umbrella, this has been a difficult task.

When NEC is established, there will be a tendency for it to wish to conduct its own R. & D. on safety beyond the narrow confines of confirmatory research. Unfortunately, NEC as a regulatory organization is not and cannot be adequately staffed to conduct good R. & D.

Undoubtedly, in a few years NEC could settle down into a routine regulatory agency and gradually get squeezed in terms of funding and staff, as so often happens with regulatory organizations. Thus, NEC could follow the fate of most regulatory agencies and end up industry dominated. Various means of preventing this possibility, through close technical collaboration with ERDA, will probably be required.

ITEMS UNFINISHED IN ERDA

Finally, I would point out two items of unfinished business which should be kept in mind for future action in relation to ERDA:

1. The need for multiyear funding for ERDA projects;

2. The transfer of other energy related R. & D. programs to ERDA. An example is the desalting R. & D. program presently conducted by the Office of Saline Water of the Interior Department. This program, which offers great potential in combination with nuclear powerplants, has been cut back severely by the OMB.

In conclusion, Mr. Chairman, let me repeat that I fully support the enactment of S. 2744. I hope my comments today may lead to some improvements in the bill or in its administration.

That concludes my testimony, Mr. Chairman.

Senator RIBICOFF. Thank you very much, Mr. Ramey. We are dealing with a very complex situation. We want to get the best bill we can and time is of the essence.

Mr. RAMEY. Right.

Senator RIBICOFF. And as you indicate, much will have to be straightened out later. While the subject matter of the bill is in the process of being put together, I do appreciate your statement and I would like the privilege of submitting some questions to you, hopefully that you might have some time to answer those questions in writing.

Mr. RAMEY. Fine.

[The material referred to follows:]

Question 1. Dixy Lee Ray, in her energy R & D survey for the President, predicted that by 1980, her proposed five-year, $10 billion program would reduce oil imports to half (six million barrels a day) of those currently projected. She sets 1985 as the earliest date by which self-sufficiency can reasonably be expected.

Do you agree with these projections?

Do you have any recommendations for shortening the time needed to reach self-sufficiency?

Answer to Question 1. While I certainly endorse—and have indeed advocated for some time—a policy of U.S. self-sufficiency in energy supplies, past experience with major energy R & D undertakings would suggest that the 1985 date is rather optimistic. In my view, it is highly doubtful that even vigorous implementation of the various R & D programs will result in the saving of 6.1 million barrels of oil per day by 1980 and 16.0 million barrels of oil per day by 1985.

While I believe we should work on the mid-term and long-term R & D programs included in Chairman Ray's report, the only course of action to reach self-sufficiency quicker is to put into effect more expeditious ways of siting, construction and operating additional nuclear power plants as well as coal-fired power plants consistent with proper environmental requirements. Each year saved in the current 9 or 10-year cycle from the date or ordering a nuclear plant to the date of commercial operation would mean the saving of millions of gallons of oil annually. The Joint Committee on Atomic Energy plans to hold hearings early in 1974 on specific legislative proposals to expedite the licensing process consistent with environmental considerations.

Expedited development work on sulphur and other pollution controls on coal-fired power plants could make a contribution to increased construction and operation of these plants at an early date.

In addition, we should build as soon as possible large scale demonstration and first-of-a-kind plants for liquefication and gasification of coal and the commercial demonstration of breeder reactor technology.

These are the steps which could, in my opinion, help substantially over the next decade or so to reduce our dependence on foreign imports.

Question 2. Dixy Lee Ray, in her energy R & D survey for the President, recommends that the greatest emphasis be placed on short-term objectives, with the greatest share of Federal funding ($4 billion) going to nuclear R & D, and next largest ($2.2 billion) going to coal conversion R & D, in a five-year, $10-billion program.

Do you agree with these recommendations?

Answer to Question 2. It should be understood that in Chairman Ray's recommended five-year, $10 billion energy R & D program, only about *$4 billion* would be additional or new funding over and above previously projected Federal funding. Of this new funding, the great majority of the money is for fossil fuel R & D, and for advanced non-nuclear R & D, such as solar, geothermal, etc. This is understandable in the historical context that the only energy R & D program in the past which has been adequately funded by Congress and the Executive branch has been the nuclear power program.

It is easy to forget that the Executive branch, industry and the appropriate congressional committees never adequately pushed R & D on coal and oil and advanced non-nuclear sources. So there is a great deal of catching up to do. But this should not be at the expense of nuclear R & D, which only received a very modest increase in Chairman Ray's $4 billion incremental recommendation.

Getting back to the specific question, actually, according to table 2.1 of Chairman Ray's report, almost $3 billion out of the $4 billion total recommended for nuclear R & D for the five-year period is directed towards mid-term objectives rather than short term. In any event, I generally agree that the greatest share of total Federal energy R & D funding should go towards nuclear and coal programs. These programs, in my view, offer the greatest potential pay-off in the next decade or so. Furthermore, the longer range programs—such as solar—are at a stage in the development process where it is not advisable, in my view, to pour large additional amounts of funds at this time.

There is a substantial question in my mind as to whether the overall level of $10 billion is adequate to do the job. In other words, aside from what the shares are among the various programs, in my view, the size of the overall program is too small. The report is banking on a significant contribution of up to $12.5

billion from industry to help do the job. While I am certainly in favor of obtaining as much industrial support as possible, past experience suggests that $12.5 billion is a very ambitious goal.

Question 3. The solution to our energy crisis will require efforts both to increase supply and reduce demand. ERDA is heavily weighted toward the supply side of the problem. The demand aspect is buried deep in one of the bureaus, where it is combined with safety and environmental concerns. To give the demand side the attention it needs, wouldn't it be desirable to establish a separate bureau devoted to this subject alone?

Answer to Question 3. While I agree that steps should be taken to make more efficient use of our energy supplies and to reduce demand where possible, I do not believe it is necessary or advisable to establish a separate bureau in ERDA for that purpose. As I understand the proposed program, many of the ERDA R & D efforts, if successful, will result in technology that will improve the utilization of energy. Further, it should be noted that in many respects reducing the demand for energy cannot be accomplished by research and development programs of ERDA.

It might be desirable in the Director's office of ERDA or in the Assistant Director for Environment Safety and Conservation, that a small staff be established to coordinate and monitor the various R & D projects throughout the ERDA program, which are of special importance from a conservational standpoint. However, the actual conduct of the R & D project should probably be placed and organized on a more functional basis.

An example of the above approach would be R & D directed toward improved mass transportation should probably be conducted by a group working on transportation R & D. Similarly the development of improved batteries for electric cars and for large-scale storage for utilities, should probably be handled by a transportation or utility R & D group. But the R & D proposals and the progress of the work should be reviewed and followed closely by the energy conservation staff. Needless to say, the wider scale use of electrical mass transit and wide use of the electric auto (even for the second car in a family) would mean great savings in foreign oil purchases and also improve the environment.

Question 4. You obviously feel strongly that ERDA should be non-political, and that the best way to assure that is to establish a three-member board rather than an Administrator, and to make the assistant administrators career, rather than Presidential appointments.

How do you respond to the argument that while the multi-member approach is suitable for a regulatory agency such as the AEC, the single-Administrator approach is more suitable for an R & D agency, such as ERDA to facilitate faster, more efficient, policy-oriented decision making?

Answer to Question 4. The above argument is the "established wisdom" oft repeated over the years by the Office of Management and Budget and others. In my opinion, it is not entirely accurate or sound.

First AEC has been primarily a multi-purpose development and production agency rather than a regulatory agency. Part of the reasons for AEC's success in developing civilian nuclear power, nuclear submarine propulsion, nuclear weapons and the production of nuclear fuels and materials has been its full-time five-member board of directors with a career General Manager reporting to it.

Over the years this multi-headed approach in AEC has provided more breadth and depth to policy and decision making than a single administrator could provide. The Commission by and large has served as a sort of full-time Executive Committee, similar to that of many large corporations, with the Chairman as slightly more equal than the other members.

It should be noted that TVA, the world's largest utility organization is administered by a three-member Board and General Manager. TVA not only operates a large power and river system, but also engages in considerable regional development activities including some research and development, particularly in agriculture and chemical engineering.

When I first joined the Atomic Energy Commission as a member in 1962, I looked into the question of a Single Administrator. I found that many of the progressive industrial corporations had, in fact, gone to an Executive Committee type of overall management not dissimilar from the Board form.

I also have observed the single administrator form of organization in the Federal Government. It has worked relatively well in NASA, although in the early days when Dr. Hugh Dryden was Deputy Administrator it operated more like a three-man Board. It should be noted also that in NASA the top programmatic posts are not headed by political appointees appointed by the President and confirmed by the Senate.

Over the years, I have also observed the other type of "single administrator" in the Federal Government; namely, the Cabinet form with a Secretary heading a Department. In my opinion this has proven to be a very poor and inefficient form of organization, and also driven by politics and political hacks.

While theoretically a single administrator is supposed to facilitate fast and more efficient decision making, the Cabinet form of organization has proven a very slow and cumbersome method of doing business. The AEC, with all its faults, has run rings around the Department of Interior, for example, in terms of making decisions and getting things done successfully.

One of the less understood advantages of a multi-headed agency is that it necessarily must hold meetings to get decisions. This means it has to have an agenda and that the staff and line organizations under the General Manager can press to get things decided, as in a normal corporation.

In a cabinet department, with Assistant Secretaries and Bureau Chiefs beholden to others than the Secretary, there is no easy communication or incentives to efficient decision making. In some ways, as is common, the incentive is not to make decisions and to continue the same old ways. This results in the cabinet Departments mostly being run by the OMB, various branches of the White House and on occasion various Congressional Committees.

What worries me is that ERDA, as presently proposed with its five political Assistant Administrators, would be more like a Cabinet Department than NASA.

Question 5. If the AEC laboratories and personnel now engaged in nuclear research were asked to devote substantial effort to other forms of energy research, would nuclear research activities under ERDA suffer for lack of laboratories and trained personnel?

Answer to Question 5. In my opinion, ERDA nuclear research and development would not have to suffer if its former AEC laboratories were asked to devote substantial effort to other forms of energy research.

It should be noted that AEC laboratories under the Economy Act for many years have been carrying on non-nuclear R & D in a modest way for other government agencies, particularly HEW and the Department of Interior (OSW). In 1971, AEC was authorized by an amendment to the Atomic Energy Act to engage in non-nuclear research and development, and AEC has been conducting a modest direct program of a few million dollars.

A further characteristic of the AEC-laboratory organization going back to the Manhattan District days has been its ability to expand or contract to adjust to large program demands.

Understandably with the above tradition, experience and legislative authority AEC has made alternative plans for substantial efforts in non-nuclear R & D. The assignment of Chairman Ray to propose a five-year program was a further step in this direction.

With the above background, I would say that AEC labs could take on additional assignments without significant effects on the nuclear R & D work. However, it would require some expansion both in facilities and personnel. But this could be handled adequately.

The only danger of non-nuclear expansion, as I pointed out in answering question 1, is that there might be a tendency to take it out of AEC's "hide" as it were. This would be inadvisable and unnecessary.

Question 6. You state (on p. 10) that the NEC cannot adequately be staffed to conduct good R & D on safety.

Would you favor specifically barring NEC from conducting such research so as to prevent duplicating research by ERDA, and to assure NEC devoting full attention to regulatory functions?

Answer to Question 6. No, I would not favor an outright bar on NEC conducting *by contract* a modest "confirmatory" R & D program in the field of nuclear safety. There are undoubtedly some small scale areas of R & D on safety where NEC would not be able to effectively require ERDA or others to carry on. NEC should have authority to carry on this type of safety R & D by contract.

But NEC should not have authority to engage in large-scale safety R & D either directly or by contract.

Moreover, there should be a strong legislative history on the necessity of two-way communication between ERDA and NEC staff on Safety R & D.

Question 7. One of the most important issues in this bill is the point at which the NEC should regulate the nuclear research and development activities of ERDA.

The legislation now provides that such regulation be limited to activities late in the development process—when commercial feasibility of experimental reactors is to be demonstrated. Is this wise?

From the standpoint of public health and safety, shouldn't NEC have authority to regulate reactors involved in early stages of ERDA's own inhouse R & D?

Existing and future uranium enrichment plants?

Nuclear fuel reprocessing facilities?

Answer to Question 7. In my opinion, the presently proposed limitations on NEC are wise. I don't believe NEC could get staffed adequately to regulate early stages of R & D. The AEC regulatory program, particularly in the last 15 years, has been primarily concerned with commercial nuclear plants and to some extent with demonstration and test reactors.

It has been my experience that the regulatory procedures and organization which have been successful for regulation of commercial plants are not necessarily adapted to early in-house nuclear R & D. For example, the AEC reactor development program under the direction of Milt Shaw developed a more stringent set of *engineering standards* than used by the AEC regulatory branch for commercial plants. These RDT standards are gradually being adopted by the AEC regulatory organization where shown to be feasible for industrial use.

Similarly RDT *quality assurance* requirements were more stringent than those used by the regulatory organization. This is as it should be. It is more expensive than commercial standards but are tailored for research and testing purposes. Again, where shown to be feasible, they can be adapted for commercial use.

From the above, it should indicate that the early stages of R & D work are not susceptible to large-scale commercial type regulation. The AEC or ERDA development organization itself has an adequate organization and requirements for maintenance of safety.

I would agree that future commercial enrichment facilities and reprocessing plants should be licensed by NEC. Present commercial reprocessing plants are licensed by the AEC regulatory organization.

There would not seem to be much need for NEC to license presently constructed AEC-owned plants.

Senator RIBICOFF. Mr. Daniel Ford.

TESTIMONY OF DANIEL F. FORD, UNION OF CONCERNED SCIENTISTS

As I understand from the staff, Mr. Ford, you have a paper with some exhibits that you are submitting, and that you want to make some extemporaneous remarks.

Mr. FORD. That is correct.

Senator RIBICOFF. Without objection, the entire statement entitled "The Nuclear Power Issue: An Overview" will go into the record as if read.

[The prepared statement of Mr. Ford follows:]

THE NUCLEAR POWER ISSUE: AN OVERVIEW

(By Daniel F. Ford and Henry W. Kendall)

INTRODUCTION

The Union of Concerned Scientists (UCS) is a Cambridge, Massachusetts-based coalition of scientists, engineers, and other professionals who are concerned with the impact of advanced technology on society. During the last 2½ years we have been engaged in an intensive technical study of nuclear power plant safety. We and now others, have found the safety assurances to be gravely defective. More recently, we have completed reviews of other aspects of the nuclear program. Since a large nuclear power plant construction program is underway in this country and throughout the world, public understanding of these critical issues is now an urgent priority.

This overview sets forth the principal conclusions of our investigations. It brings into focus some of the important public safety problems associated with nuclear power. For the convenience of those who wish to investigate the nuclear safety problem further, we have provided extensive references. A set of reprints

of key articles published in the last two years concerning the nuclear power program is also attached. Other groups of scientists have carried out independent reviews of our conclusions. Summaries of these reviews are presented as part of the main report. Finally, we include an appendix to the overview setting forth the comments of scientists and public figures on the contributions of UCS relating to nuclear power plant safety.

THE REACTOR SAFETY PROBLEM

We believe that nuclear power plants, as now designed, present a very serious threat to the health and safety of the public. The safety systems installed in presently operating nuclear power plants are crude and untested. A number of design weaknesses in these safety systems have been confirmed. Moreover, there is extensive evidence that the workmanship going into nuclear power plant construction is far from adequate. The increasing number of quality assurance problems, maintenance deficiencies, management review oversights, and operator errors is disturbing. The Atomic Energy Commission (AEC) itself has acknowledged that there have been a number of "near misses" in the brief operating history of commercial reactors, accidents that could have resulted in major public health incidents. An official AEC assessment of some of the operating records of the nuclear reactor program is that the absence of direct injury to the general public to date is "largely the result of good luck." [1]

THE CONSEQUENCES OF A MAJOR NUCLEAR POWER PLANT ACCIDENT

A major accident in a nuclear power plant has the potential to create a catastrophe of very great proportions. In 1971 UCS carried out a technical assessment of the consequences of such an incident.[2] In this study we applied knowledge acquired in previous studies on the effects of nuclear weapons explosions. The AEC has itself completed a secret study on the consequences of a major nuclear power plant accident; the results of the AEC investigation have recently been made public, although not voluntarily, and confirm our independent assessment.

The size and scale of a reactor accident is the consequence of the prodigious quantities of radioactive material contained inside these complicated machines. A typical nuclear power plant routinely contains a quantity of radioactive material that is approximately equivalent to the radioactive fallout from thousands of Hiroshima-size nuclear weapons. An appreciable fraction of this radioactive material is gaseous in form and could be easily borne away by the wind if accidentally released by a nuclear power plant accident. A release of even a small fraction of a reactor's inventory of radioactive material could, depending on weather conditions, cause *lethal* injuries at distances up to several dozen miles from the reactor and damage to health at far greater distances. The AEC's secret study of the consequences of a major reactor accident estimated an "area of disaster . . . equal to that of the State of Pennsylvania.[3]

Given the defects in nuclear power plant workmanship, operating procedures, and safety systems, discussed below, we believe that the possibility of a major accident involving a catastrophic release of radioactivity into the environment is very real.

THE "ECCS" CONTROVERSY

The "ECCS"—emergency core cooling system—is a very basic reactor safety system. Its function is to restore cooling water to the hot nuclear reactor core in the event that a pipe rupture causes loss of normal cooling water. If this backup cooling system fails to work effectively, the reactor core would overheat and the stage is set for the kind of major radiation release into the environment described above.

It has become apparent from our technical studies [4] that very much less than the extremely high level of diligence required has been devoted by the nuclear industry

[1] AEC Division of Reactor Licensing, *Reactor Operating Experiences*, ROE–69–9.
[2] Ian Forbes, Daniel F. Ford, Henry W. Kendall, *Nuclear Reactor Safety: An Evaluation of New Evidence*, Union of Concerned Scientists, July 1971.
[3] AEC internal memorandum from Albert P. Kenneke, Minutes of Steering Committee on Revision of WASH–740, January 28, 1965.
[4] Daniel F. Ford and Henry W. Kendall, *An Evaluation of Nuclear Reactor Safety*, Volume I, Union of Concerned Scientists, March 1972;
Daniel F. Ford and Henry W. Kendall, *An Evaluation of Nuclear Reactor Safety*, Volume II, Union of Concerned Scientists, October 1972;
Daniel F. Ford and Henry W. Kendall, *An Assessment of the Emergency Core Cooling Systems Rulemaking Hearing*, Volume III, Union of Concerned Scientists, April 1973.

reactor safety system design and testing. An array of design defects in present ECCS is apparent. The ECCS testing program has been narrow in scope and of a calibre very much below the capabilities of engineering science. There is a large backlog of unanswered questions about the most basic aspects of ECCS performance. It is clear that adequate experiments to confirm ECCS effectiveness have not been carried out. Moreover, our study of the limited experiemental data available suggests that there are a number of independent reasons why present ECCS might fail if called upon.

Our assessment of ECCS effectiveness is quite widely shared by the community of scientists familiar with reactor safety technology. The AEC's own ECCS research scientists, whose work and views we are intimately familiar with, do not believe that available information confirms ECCS effectiveness. UCS carried out analyses of safety system weaknesses in 1971 whose consequence was to force the AEC to hold a public hearing in which the views of these AEC scientists, given as sworn testimony under cross-examination by our attorneys, could be put on the public record. The most senior and experienced AEC safety research scientists expressed their disavowal of present AEC safety policy.[5] And AEC internal memoranda, which we forced onto the public record, support our fundamental criticism of AEC policy. For example:

Dr. Morris Rosen, then Technical Advisor to the Director of Reactor Licensing at the AEC, wrote that the "consummate message" from AEC safety analysis was that reactor safety system performance "cannot be defined with sufficient assurance to provide a clear basis for licensing." [6]

George Brockett, a leading ECCS researcher identified by the AEC Regulatory Staff as one of the country's leading experts in reactor safety technology, testified that present AEC reactor safety analysis was "unverified," "inadequate," "incomplete," and "uncertain." [7]

J. Curtis Haire, the man who was in charge of the AEC's primary research effort on reactor emergency cooling systems, testified that the AEC was "censoring" reports from his safety research laboratory to prevent the Congress from raising embarrassing questions about nuclear power plant safety.[8]

Our group has received, from sources within the AEC, hundreds of AEC internal documents replete with fundamental criticisms of the effectiveness of basic reactor safety systems. For example, an AEC internal memo from Milton Shaw, then head of the civilian nuclear power program, to R. E. Hollingsworth, General Manager of the AEC, stated:

"Although test information is available on the response of simulated fuel pin bundles to a range of energency coolant flow conditions, no assurance is yet available that emergency coolant can be delivered at the rates intended and in the time period prior to clad and subsequent fuel melting due to decay heat generation." [9]

In aggregate, the AEC's internal reactor safety studies and the public testimony of the leading AEC safety experts document the clear concensus of AEC safety experts that effectiveness of the important reactor safety system, the ECCS, has not been demonstrated.

CONFIRMATION OF UCS CONCLUSIONS

As a result of the accumulated evidence on ECCS, several groups of scientists, independent of UCS, have reached conclusions about reactor safety similar to our own:

The Reactor Safety Committee that advises the German government (Federal Republic) has recommended a moratorium on reactor operating licenses until more research on ECCS is completed; [10]

The Federation of American Scientists, following a review of the ECCS issue, has identified extensive deficiencies in AEC safety research and has called for broad restrictions on nuclear power plant operation together with increased emphasis on alternative power generation technologies; [11]

[5] Daniel F. Ford and Henry W. Kendall, "Nuclear Safety," *Environment*, Vol. 14, No. 7, September 1972; Robert Gillette, "Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," *Science*, Vol. 176, No. 4034, May 5, 1972.

[6] AEC internal memorandum from M. Rosen and R. Colmar to ECCS Task Force, June 1, 1971.

[7] George Brockett, et al, *Loss of Coolant/Emergency Core Cooling Augmented Program Plan*, August 1971.

[8] Testimony of J. Curtis Haire, April 6, 1972, AEC Docket No. RM-50-1, Tr. pp. 7591-7593.

[9] AEC internal memorandum from Milton Shaw to R. E. Hollingsworth, February 19, 1971.

[10] AEC internal memorandum from Andrew J. Pressesky, Assistant Director for Nuclear Safety, Division of Reactor Development and Technology, to Milton Shaw regarding German moratorium, May 8, 1972.

[11] Federation of American Scientists Newsletter, February 1973.

The RAND Corporation, well-known for its work for the Defense Department, stated in a report to the California Assembly that ECCS effectiveness was an "unresolved" issue and that "Until those questions are resolved, it is unwise to plan for the rapid proliferation of nuclear power plants."; [12]

The AEC's Advisory Committee on Reactor Safeguards (ACRS), its foremost safety assessment committee, has listed "ECCS capability" on its list of presently unresolved reactor safety problems.[13] In September 1973 the ACRS wrote to the AEC with an urgent recommendation on the need for "significant improvements" in ECCS; [14]

The California Assembly's Advisory Committee on Science and Technology reported that, "Not enough information exists to determine if the [ECCS] systems are adequate."; [15]

Swedish government scientists (investigating ECCS systems on reactors that Sweden purchased from U.S. manufacturers) have concluded that ECCS effectiveness has not yet been established. [16]

The public, obviously, cannot accept the "say-so" of the nuclear industry about reactor safety. Objective scientific evidence relating to reactor safety must be provided. It is most noteworthy that all of the technical reviews of ECCS effectiveness by groups such as ours, who are independent of the nuclear industry, have reached the same conclusion. (We have listed above all of the independent reviews of the ECCS issue that have been made public.) The existence of such strong doubts of ECCS effectiveness among scientists who have investigated this issue should warn the public that AEC safety assurances are open to serious question.

RADIOACTIVE WASTE STORAGE AND OTHER PROBLEMS

In addition to major reactor accidents, the reactor program is beset by other difficulties. One of the most important of these problems involves the storage and disposal of radioactive wastes. The radioactive wastes created in nuclear power plants are extremely toxic and persistent poisons. These radioactive wastes will have to be stored—somewhere, somehow—for tens or hundreds of thousands of years. They can never be allowed to return to the environment. Nuclear power plants are expected to have a service life of no more than about 40 years. Yet the wastes they create will become a legacy from this transient existence to future generations for nearly geological periods of time.

According to the AEC, no technically or economically feasible method for long-term storage or disposal of radioactive wastes is yet available.[17] All proposed techniques for storing these wastes are in a research and development stage. Many people have come to believe that present nuclear power plant construction plans, which imply accumulation of more radioactive wastes, should be halted until a proven method for safely storing radioactive wastes is available.

The AEC has already experienced major difficulties in storing the wastes accumulated from the nuclear weapons production program. For example, in June of this year it was discovered that 115,000 gallons of high level radioactive waste had leaked from a tank at the AEC's waste storage facility in Hanford, Washington.[18] The official investigation [19] revealed that the tank had been leaking for several weeks, that no automatic alarm system alerted anyone to the leak, that the management in charge of the storage facility did not review monitoring reports that would have shown the leak, that there was no preventive maintenance applied to the monitoring equipment, and that persons with responsibilities for overseeing the storage of these waste materials had no formal training to assist them in the execution of these important responsibilities. All in all, we are profoundly disturbed by the prospects of accumulating radioactive wastes that the country does not have the secure technology to cope with and which we are today dealing with in a supremely careless manner.

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[12] R. D. Doctor, et al, *California's Electric Quandary*, R-1116-NSF/CSA, September 1972.

[13] Letter from C. P. Siess, Chairman, ACRS, to James R. Schlesinger, Chairman, AEC, December 18, 1972.

[14] Letter from H. G. Manglesdorf, Chairman, ACRS, to Dixy Lee Ray, September 10, 1972.

[15] Assembly Science and Technology Advisory Council Report to the California Legislature, *Nuclear Power Safety in California*, May 1973.

[16] Statement of Dr. Björn Kjellstrom, AB Atomenergi, Miljocentrumkonferens, Uppsala, Sweden, June 14, 1973.

[17] F. K. Pittman, *Management of Commercial High-Level Radio active Waste*, a paper presented at a summer course on Nuclear Fuel and Power Management, Mass. Institute of Technology, Cambridge, Mass., July 25, 1972.

[18] Union of Concerned Scientists letter to AEC, June 23, 1973.

[19] USAEC, *Report on the Investigation of the 106 T Tank Leak at the Hanford Reservation, Richland, Washington*, July 1973.

Another public safety and national security issue associated with nuclear power plants is the theft of special nuclear materials. This class of materials, which includes certain types of uranium and plutonium, may be used to construct nuclear weapons. As more and more reactors come into operation, the quantity of these materials present in the nation will increase. The theft of these materials as they are transported routinely through the notoriously insecure commercial transportation network, can be used as the basis for blackmail and terrorism. The principal obstacle that a terrorist group would face in the fabrication of a nuclear weapon is the acquisition of the special material from the reactor program. It is within the capability of sub-national groups (e.g., "Black September") to construct a nuclear weapon from such materials that are available in the commercial nuclear power program. Moreover, given the hazards of plutonium, it would not be necessary to turn this material into a weapon in order to undertake a terrorist campaign. The threat simply to disperse this immensely toxic material, among the most potent of cancer-causing agents, would be adequate for the terrorist purposes. (A quantity of plutonium the size of a grain of pollen is sufficient to cause lung cancer in mammals.)

A host of subsidiary problems—cancer among uranium miners, the public safety hazards from residues from uranium mining, emissions of radioactive materials for nuclear fuel reprocessing plants—would complete the list of public safety considerations which must be entertained in connection with a review of the risks associated with nuclear power plants.[20]

IMPLICATIONS

The public safety problems associated with nuclear power constitute, in our view, ample justification for a curtailment in this country's nuclear power plant construction program. It is clear that no public airing of these important safety issues was made prior to the startup of the present reactor construction boom. Indeed the magnitude of the present hazards was not even fully identified. Instead, the AEC quietly worked with U.S. reactor manufacturers and utility companies to promote a dream that they mutually shared: cheap, abundant, safe electric power. We, and others who have made detailed scientific and technical investigations of the nuclear power program and who, because of our position outside the nuclear industry, are able to speak freely, have come no longer to regard nuclear power as a dream but as an ultrahazardous technology that it is now wise to deemphasize and to avoid.

Appendix 1.—Comments by Scientists and Public Figures on the Contributions of the Union Concerned Scientists Relating to Nuclear Power Plant Safety

1. AEC internal memorandum from Donald B. Trauger, Associate Director, Oak Ridge National Laboratory, to Milton Shaw, Director, Division of Reactor Development and Technology, AEC, November 24, 1971:

"Three members of the Union of Concerned Scientists (USC) met with members of the ORNL staff. . . . We felt that the technical publications of this group, as well as their professional integrity, justified our meeting with them . . .

"The visiting scientists were Henry W. Kendall, physicist (MIT); Daniel F. Ford, economist (Harvard University); and James J. MacKenzie, physicist (Audubon Society). . . .

"The three members of the Union of Concerned Scientists who visited here appeared to be well educated and dedicated people. According to them, they had not received satisfactory answers from either the utility or the vendor in the case of the Pilgrim reactor as to some of the issues raised in their papers, so they felt compelled to undertake the intervenors' role. In pursuit of this role they have become intimately familiar with the relavent published literature and have even received some 'proprietary' information from at least one vendor. Their experience led them to examine this situation very closely, and they have become aware of various deficiencies in the case for ECCS performance in a LOCA."

2. Dean E. Abrahamson, University of Minnesota, writing in *Environment* January/February 1973:

". . . largely through the work of the Union of Concerned Scientists, nuclear safety and the adequacy of the emergency core cooling systems have been effectively challenged."

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[20] The public safety problems associated with the nuclear fuel cycle, summarized here, are discussed in a forthcoming major report from the Union of Concerned Scientists.

3. Dr. Richard Balzhiser, Office of Science and Technology, Executive Office of the President, speaking at the University of Michigan, Ann Arbor, April 13, 1973:

"I commend the effort that they [The Union of Concerned Scientists] have spearheaded in focusing attention on important problems in the reactor program."

4. Ralph Nader on ABC-TV "Dick Cavett Show," December 13, 1972:

"They [The Union of Concerned Scientists] have performed a public service, Dick, which will go down in history. In terms of what they got the Atomic Energy Commission to admit they did not know, and the way they helped the conscientious scientists in the National Laboratories run by the Atomic Energy Commission to begin to weigh these risks and seriously try to grope for the truth, instead of trying to grope for some sort of face-saving obstinancy that keeps making the same mistakes."

5. Charles Warren, Chairman, Subcommittee on State Energy Policy of the California Assembly's Planning and Land Use Committee, in a letter of May 16, 1973 to Dr. H. W. Kendall:

"This is to thank you and Dr. Ford for appearing before our Subcommittee on State Energy Policy.

"Your testimony expanded most helpfully the comments by the Rand Corporation concerning the wisdom of reliance on nuclear reactors for the generation of electricity to the extent industry plans forecast. The witnesses for the Atomic Energy Commission who appeared subsequent to you did not materially detract from your facts, although they attempted to reassure us conclusions need not be so ominous. In this effort, they were not successful."

6. E. G. Struxness, Director, Environmental Impact Reports Project, Oak Ridge National Laboratory, U.S. AEC:

"The two reports prepared by the Union of Concerned Scientists . . . are certainly very persuasive in their presentation. You are probably aware that this organization was the prime mover in instigating the Hearings on Acceptance Criteria for Emergency Core Cooling Systems for Light Reactors (ECCS)."

7. Federation of American Scientists Newsletter, February 1973:

"FAS CONCERNED OVER NUCLEAR REACTOR SAFETY"

" . . . we see great importance in the recent Union of Concerned Scientists documents on light-water power reactors. We believe that UCS has performed a most useful public service in forcing a public debate on the questions of reactor safety in general, and the Emergency Core Cooling Systems in particular. In the opinion of some of us, who have examined the problem, their documents have shown that existing Government studies do not support the reliability of the emergency systems designed to cool the reactor in the event that its cooling water is suddenly withdrawn due to accident or sabotage."

APPENDIX II.—REPRINTS OF SOME RECENT MAGAZINE ARTICLES ON NUCLEAR POWER PLANT SAFETY [1]

"Nuclear Safety," *Environment*, September 1972, Vol. 14, No. 7, p. 2.

"Cooling Water," *Environment*, January/February 1972, Vol. 14, No. 1, p. 40.

"Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," *Science*, May 5, 1972, Vol. 176.

"Nuclear Safety: Damaged Fuel Ignites a New Debate in AEC," *Science*, July 28, 1972, Vol. 177.

"Nuclear Safety (I): The Roots of Dissent," *Science*, September 1, 1972, Vol. 177.

"Nuclear Safety (II): The Years of Delay," *Science*, September 8, 1972, Vol. 177.

"Nuclear Safety (III): Critics Charge Conflicts of Interest," *Science*, September 15, 1972, Vol. 177.

"Nuclear Safety (IV): Barriers to Communication," *Science*, September 22, 1972, Vol. 177.

"Reactor Safety: AEC Concedes Some Points to Its Critics," *Science*, November 3, 1972, Vol. 178.

"Nuclear Safety: AEC Report Makes the Best of It," *Science*, January 27, 1973, Vol. 179.

"Radiation Spill at Hanford: The Anatomy of an Accident," *Science*, August 24, 1973, Vol. 181.

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[1] Available in subcommittee files.

Senator RIBICOFF. You may proceed, sir.

Mr. FORD. Thank you.

The Union of Concerned Scientists is a Cambridge, Mass., based coalition of scientists, engineers, and other professionals who are concerned with the impact of advanced technology on society. The UCS was formed in 1969 as an informal group of MIT faculty members who wanted to do pro bono reviews of technological issues.

Senator RIBICOFF. Is it based mostly on the faculty members of MIT or are there others involved?

Mr. FORD. It is based principally on faculty members at MIT, some people at Harvard, Brandeis, and other local colleges and some people who work professionally in engineering organizations in the Boston area.

Our studies on the nuclear power issues are what I want to talk about today. To investigate this subject, we have assembled a group of nuclear physicists, nuclear engineers, doctors, biochemists, and persons familiar with the international security problems. By training, I am an economist. I started my work at Harvard in a project studying the costs and benefits of nuclear power.

REACTOR SAFETY PROBLEMS

During the 2½ years that we have been involved in the technical reviews of nuclear power, we have identified some very serious and quite unresolved reactor safety problems; we have published our technical studies and distributed them quite widely to the scientific community. As a result of these studies, additional studies have been undertaken by various independent groups; that is, independent of the AEC. The Rand Corp., for example, the think tank out in California that works for the Department of Defense, undertook a review of California's electricity situation on behalf of the California State Assembly, and in particular the reactor safety questions. They concluded that there were quite serious reactor safety problems that were unresolved, and they recommended to the State of California that it was unwise to continue with the rapid construction of nuclear power plants until these safety problems were resolved.

RADIOACTIVE POLLUTION

Most recently, the Pugwash Conference on Science and World Affairs, an international movement of scientists, set up a working group on radioactive pollution of the environment. And as you may know, the Pugwash working group reports are seldom made public; the purpose of Pugwash is to advise governments on various high technology issues. But because of the special significance of their findings on nuclear power, they released the working group paper.

The working group paper concluded, and I quote:

> Owing to potentially grave and as yet unresolved problems related to waste management diversion; that is, theft of fissionable material and major radioactivity releases arising from accidents, natural disasters, sabotage or acts of war, the wisdom of a commitment to nuclear fission as a principal energy source for mankind must be seriously questioned at the present time. Accordingly, research and development on alternative energy sources, particularly solar, geothermal and fusion energy, and cleaner technology for fossil fuels, should be greatly accelerated.

The Pugwash group consisted of a number of distinguished physicists, health physicists, geologists, chemists from national academies

of various European countries, as well as some of the American scientists who indeed played a major role in developing nuclear power in the first place.

The proposed legislation that is being considered here today of course provides for continued development of a major reliance on nuclear power. And furthermore, the Atomic Energy Commission regulatory staff under a new name is given continuing responsibility for the licensing of nuclear powerplants. But we submit, in view of the accummulated evidence from various independent reviews by scientists on such issues as the possibility of catastrophic accidents, that it is appropriate in considering this legislation to ask whether the Nation should continue to develop a major reliance on nuclear power.

SAFETY AND RELIABILITY PROBLEMS

It is also appropriate to ask whether the Atomic Energy Commission regulatory staff, which has of course been operating since 1961 as a separate entity in the AEC, has in fact been serving to protect the public health and safety in an adequate manner. Should the AEC regulatory division, that is, simply be renamed and set up as a separate organization and allowed to continue business without any significant overhaul?

We are, of course, concerned with this legislation because we want to avoid energy supply difficulties in the future, and nuclear power has been offered as a means of meeting future energy requirements. But I think that we must realize that it does not make sense to substitute a long-run radioactivity crisis for the present energy crisis.

As the New York Times observed in an editorial on December 3, 1973, "Little is gained by replacing a politically unreliable fuel—oil—with technically unreliable and potentially dangerous powers from nuclear fission."

Now, when I speak of the unreliability of nuclear power, I mean that in several senses. I mean it in the sense that first of all, it is unreliable in that if the plants cannot be operated in a safe manner, if they are susceptible to large-scale accidents, then obviously as these accident experiences occur we will in fact have to curb the operation of the plants. Today if nuclear powerplants are performing unreliably just in general economic terms—various breakdowns and so forth—it does not make very much difference to our Nation's energy supply. They only supply about 1 percent of our total energy.

On the other hand, if we allow nuclear powerplants to continue to be built in large numbers without first making sure that these safety problems are resolved, we may find ourselves in a situation 10 or 15 years into the future when nuclear powerplants, No. 1, become a major supplier of electricity, and No. 2, they have to be curbed in operation because of safety problems that have developed to a very serious point.

So the fact of the matter is that we must be sure, prior to developing a major dependence on nuclear power, that we will not be surprised in the future by the fact that we have to shut them off or run them at lower rates of power because of their developing safety problems. Continuing to build nuclear powerplants with unresolved safety problems, in short, creates a major uncertainty regarding future electric power supplies.

Moreover, in discussing the question of nuclear powerplant reliability, we have to consider reliability in conventional terms, simply whether they will stay on-line and provide on a continuing basis the power that we need. The Wall Street Jorunal on May 3 of this year carried a front page special feature entitled "Atomic Lemons." It was about the various breakdowns at nuclear powerplants that are so grievously affecting their reliability.

Senator RIBICOFF. What I do not understand is why these large utility companies make such huge investment in plants that may be unreliable, that they may not be able to use and will not deliver the energy.

How do you explain that, because according to you and according to these articles, there has been such a bad experience, supposedly?

Why do they continue making these investments?

Mr. FORD. Well, the utility companies, I think, are basically not very adept at dealing with advanced technology. They do not have inhouse capability for analyzing nuclear safety problems. They have simply been in the position of taking the word of both the manufacturers and the Atomic Energy Commission that the plants are everything they are claimed to be.

NUCLEAR PLANTS CANCELED

However, I think that is changing. There are a number of utility companies which are getting out of the nuclear power business. For example, Baltimore Gas & Electric has canceled plans for two nuclear plants that it had previously ordered because it was afraid that the safety regulations would have to be changed in the future to accommodate new safety problems. Consolidated Edison Co. has canceled plans for, I believe, six nuclear powerplants, two on the Hudson River and one set of four plants that was proposed for David's Island.

Senator RIBICOFF. I thought they were going ahead with Storm King.

Mr. FORD. That is a pump storage plant, Senator. I am talking about the Indian Point four and five projects, two nuclear plants that were formerly scheduled to be built next to the three that they already have on the Hudson River. And they had leased David's Island, which is off New Rochelle—where Fort Slocum used to be—as a site for four nuclear plants. They have canceled those plants as well.

The Florida Power & Light Co. is also reported to be giving up on further nuclear powerplant construction projects.

Senator RIBICOFF. Well, if there is this skepticism and if there is this experience from industry itself, where is the push for additional nuclear fission plants?

Where is that coming from?

Mr. FORD. Well, I think the principal push is that the utility companies are quite afraid of the political unreliability of imported oil. It seems, from my talking to utility executives, that this is the principal reason why utility companies want nuclear power. They may take very much longer to build. They may have these routine breakdowns—operating problems—and they may subject the utilities to much greater difficulty in getting them licensed. But basically there is enough

domestic uranium available so that there is no question about the long-term supply of fuel. That is my understanding.

Senator RIBICOFF. Well, since the country now is pushing toward oil shale and liquefaction, gasification of coal, tides, winds, solar energy, does this give the utilities a different overview of the problem?

IMBALANCES IN RESEARCH PROGRAMS

Mr. FORD. Well, I think the fact of the matter is, Senator, that because of the imbalances in the research programs that have been carried out in the last few decades, nuclear power is sitting there on the shelf as an option which one can say yes or no to. The other alternative technologies are in a research and development or pilot project stage, and utility companies are facing in their estimates of horrendous increases in electric power demand over the next 10 or 15 years. And in terms of their way of looking at the problem, this simply is no alternative. The society at large can discuss whether the demand should be curbed, whether by, for example, changing the price structure—it can be mitigated instead of giving an incentive to use more energy through volume discounts. We give an incentive to use less through volume penalties. To cite another case, we can change building codes to insist that our buildings do not leak heat like sieves. Thus, society at large can address the energy demand situation, but this is beyond the utility companies. They have no power to promote energy conservation in the ways that I have outlined.

Senator RIBICOFF. Well, will you explain the difference between fission, breeder, and fusion?

FISSION POSES POTENTIAL DANGER

Mr. FORD. Fission is a reaction in which heavy elements, uranium-235, are split apart.

Senator RIBICOFF. And that is the method that concerns you the most as to the potential danger, is that right?

Mr. FORD. That is correct. The present generation of fission nuclear powerplants.

The second technology you mentioned is the so-called breeder reactor. It is a fission reactor.

Senator RIBICOFF. Breeder is a fission reactor. Is that safer or does that have the same problems as fission?

BREEDER REACTOR SAFETY

Mr. FORD. It is generally believed, Senator, that the breeder reactors have much more pronounced safety problems than the light water reactor. For example, if in the light water reactor, you lose the cooling water, the nuclear chain reaction stops and the reactor shuts down—which is a good thing.

On the other hand, because of the nuclear physics of a breeder reactor, if you develop bubbles in the coolant because of an inadequate coolant flow, the nuclear chain reaction goes faster, so the inherent mechansim that you have in a light water reactor to shut the reactor off is not available in the breeder; indeed, quite the opposite situation obtains.

FUSION PROCESS

Now, to go on to the third technology you mentioned, fusion. Fusion is the process of taking very light atoms and fusing them together. It is at the precise opposite end of the spectrum from fission. Fusion, of course, has not been demonstrated as a technical possibility, controlled fusion that is. Of course we have fusion in the hydrogen bomb, but controlled fusion is not demonstrated as a technical possibility, although it is very well worth major effort to find out. And the fusion operation, as the scenario is sketched, does not present any of the safety problems that we find apparent in the fission reactors.

Senator RIBICOFF. How long do you think it will take to develop a fusion reactor?

Mr. FORD. I do not believe that I can give you a reliable estimate on that. I think the people doing the fusion work itself would be in the best position to do that. I have heard, of course, discussing it with these people, talk in terms of perhaps having fusion developed in 30 years.

Senator RIBICOFF. In 30 years. In other words, it is that difficult and that esoteric that it will take 30 years to develop it?

Mr. FORD. That is correct. You are talking about replicating conditions in the center of the sun. You have tremendous materials problems. When you deal with fission reactors, the engineering there is applying known technology. In fusion they are trying to develop basic science as they go along. It is a much more difficult proposition, and no one proposes that fusion can be, within the short term, a solution to our energy problems.

NUCLEAR WASTE

Senator RIBICOFF. Now, you cite the lack of technology for safely disposing of nuclear waste as a major obstacle in the development of nuclear power generators. Dixy Lee Ray's survey recommends that $790 million be spent by 1980 on reactor safety reliability performance, including waste disposal.

Do you think that, considering all the problems, that this can be done?

Are you for abandoning the whole concept of nuclear energy?

CARELESS ENGINEERING

Mr. FORD. Not at all, Senator. We have never identified any reason in principle why these water-cooled reactors which they are building today could not have been developed so that they presented an adequately small risk. What we are dealing with is a matter of careless engineering that has gone on over the past decade as a result of lax regulation by the AEC. But our recommendation is for a major research program to be undertaken on reactor safety so that we can clarify these problems, and, if the problems are settled in an adequate way, we can then use fission power. Of course, radioactive waste disposal and safeguards problems must also be solved.

Senator RIBICOFF. In other words, your attitude and your point of view is not that we should eliminate completely the concept of nuclear energy through the fission process. Your complaint is that not enough

is done to assure safety, and there is not sufficient research, but that research could be brought about to make fission safe.

Do you believe it can?

Mr. FORD. As far as the water cooled reactors are concerned, we believe that to be the case. You can design a reactor that will not be susceptible to the type of accidents to which the present water reactors are susceptible.

Senator RIBICOFF. Well, are there such reactors on the drawing board safely designed?

BACKGROUND ON SAFETY ISSUE

Mr. FORD. Well, basically—let me give you a bit of background as to what the safety issue is, and then we can discuss what can be done about it, if that will be useful.

Nuclear power reactors accummulate, as they operate, prodigious quantities of radioactive material. These are the fragments from the split uranium nuclei. In quantity, they measure 10^{10} curies, which is equivalent to the fallout from thousands of Hiroshima-sized nuclear weapons. These radioactive wastes are very hot, and even if the reactor is shut off the wastes still continue to generate their heat.

Senator RIBICOFF. What is happening to that waste now?

Mr. FORD. Well, in normal circumstances this material is housed inside of the nuclear powerplant. And what we are concerned about in the first instance is some type of accident involving the release of quantities of radioactive materials sufficient to cause major public health consequences at great distances from the reactor.

A 1965 SECRET STUDY

Back in 1965, the Atomic Energy Commission carried out a secret study on the consequences of a reactor accident. The study was conducted by a task force of senior AEC management personnel together with scientists at the AEC's Brookhaven National Laboratory. They had sophisticated computer calculations that predicted what would happen if certain plausible events took place inside the reactor—if a pipe ruptured and the normal cooling water were lost, and the critical safety system—the emergency cooling system—did not work.

They calculated what would happen to the people living in the vicinity of the plant, and they made an estimate of what they termed "the killing distance," that is, the distance from the actual damaged reactor which lethal injury could be received. They estimated it was several dozen miles from the reactor. Some of the typical calculations they carried out showed 45,000 casualties from this type of accident.

The Brookhaven people stated that "the area of disaster" from a nuclear powerplant accident could "equal the size of the State of Pennsylvania."

Now that is, of course, an unacceptable occurrence. The next question to be asked, and this was asked in the secret study, is, what is the likelihood of that type of accident? The minutes of the secret meetings stated that the probability issue was "the most difficult encountered by the committee." The central problem is that they did not have sufficient data to make a quantitative estimate. The head

of the study stated that all that can be said is that the probability of a major accident is "believed to be small."

The minutes of the committee meetings indicated the probability discussions "went nowhere." They also pointed out that during the brief operating history of the nuclear porgram there had been a number of events which they characterized as "near-misses"—bolts cracked at critical locations, pipes damaged in very dangerous ways—and they said that these near-misses could easily have developed or easily been extended into major accidents. The reason why they have not had a major accident to date is attributed by the AEC to "good luck."

And so, to put the whole safety question in perspective, we are talking about an event that is on a scale that is simply unknown in this country in time of peace. You have asked, What is on the drawing board? Basically the Atomic Energy Commission has a few types of reactors which they are licensing and propose to license in great number around the country. The designs for these kinds are largely fixed. We have been committed in this country to about 200 nuclear powerplants. So that, between now and 1980, our future in terms of reactor design has been pretty much programed by the AEC. There are some design changes which they are talking about to make some improvements in emergency cooling systems. But in our mind the type of design changes being entertained are of unproven value.

Senator Ribicoff. I know, but does your group have recommendations for design changes that would eliminate or minimize accidents?

Mr. Ford. We do not believe that there is sufficient understanding of the underlying situation in a reactor so that an adequate design change can be proposed. One of the central problems with their research is that they have not done enough to know what happens inside a nuclear reactor in the event of an accident. You cannot fight an enemy that you cannot define.

Senator Ribicoff. Well, would you stop completely the building of nuclear plants?

Mr. Ford. Well, what we would suggest is the following. We have 39 nuclear plants now operating in the United States. There are, I believe, 55 or 56 under construction. We believe that these plants should be allowed to operate, although under a speed limit. Since you are concerned with the reactor's overheating in an accident, if you run them at lower power level you increase the margin of safety that they will not overheat.

We do not think that it is practical, given the fact that these plants are already in the pipeline, we simply do not think it is practical to stop them entirely. But we do think that new plants should not be built until the flaws that are identified in reactors of present design are corrected.

Senator Ribicoff. Well, who is going to make that decision as to whether they are corrected or not, or whether they are safe or not?

Who is going to make that decision?

Mr. Ford. Well, I think this is the type of decision that one would hope that an independent agency with technical competence could make. Unfortunately, the situation has developed to the point where the agency which was set up to make that kind of decision, the Atomic Energy Commission, has largely defaulted.

SUPPRESSED AEC DOCUMENTS LEAKED

Let me tell you a little more about the secret study. During the past few years, people in the AEC concerned about AEC policies and practices have leaked to us several thousand pages of AEC documents. We have also vigorously applied the Freedom of Information Act to obtain more material. What is quite apparent from this documentation is that the Atomic Energy Commission has been engaged in a very large-scale and systematic attempt to suppress and secrete information dealing with urgent reactor safety problems. I mean, for example, the secret study told about the enormous consequences of a major accident and their inability to say how likely or unlikely such accidents were. The study was not made public, and the minutes of the study's steering committee show that the reason it was not made public is that the AEC was afraid that the Congress and that the general public would respond and stop the nuclear power program. Senior agency officials stated at one secret meeting that the results of the study must be revealed to the Commission; that is, to the five Commissioners of the Atomic Energy Commission, "without subterfuge, although the method of presentation to the general public has not been resolved." And of course, it was ultimately resolved, and they decided to suppress the entire study. They stated, senior regulatory staff officials, who are obviously familiar with the applicable law, that if the results of this study were made public, legal action to halt further reactor construction might be taken.

Third, the steering committee members stated that the results of this, the secret study, could easily be extrapolated to be applied to nuclear powerplants that would be applying for licenses in the next several years.

And finally they observed that the scientific community at large would be alerted by this study to the enormous hazards associated with nuclear power.

There is much other documentation in these thousands of pages of internal files that we have to indicate that the AEC has been largely concerned with promoting nuclear power. They do not want to license unsafe reactors—but what they hope is that they have time, that they can allow the plants to operate, and at the same time they will do some safety research, so that some time in the future all these safety issues will be settled.

AEC AWARENESS OF SAFETY

Senator Ribicoff. Is the Atomic Energy Commission aware of whether what they are doing is safe at the present time?

Are they concerned over this?

Mr. Ford. I think that they are greatly exercised over this problem. For example, the AEC's principal basis for assuring reactor safety is the proposition that the quality of reactor construction is really crackerjack, that everything is done in such a nifty way that it is highly unlikely that things would go wrong. They call this their quality assurance program.

Well, recently—and I have the material to submit for the record here—both AEC Commissioner Doub and the Director of Regulation at the Atomic Energy Commission, Mr. Muntzing, had talks to all

the various utility companies that operate nuclear powerplants, and what they told them is that the quality assurance program is not working well at all, that during an 18-month period from January 1972 to June 1973 there were 850 abnormal occurrences at nuclear powerplants, that a large fraction of these showed that there were generic safety problems with the plants; that they related to extensive defects in the way the plants were designed and constructed and operated.

So I think the Atomic Energy Commission has recognized that these problems exist. Indeed, what the internal memoranda of the AEC show is that the AEC's own experts have been telling them for years about the existence of these serious safety problems.

As we refer in pages 6 and 7 of this document that we are submitting today, the man who was in charge of emergency cooling systems review at the AEC, a basic safety system, told the AEC at the same time they issued policy statements saying the emergency cooling problems were well in hand, he told the AEC that "the consummate message" from their safety analysis was that the performance of the system "cannot be defined with sufficient assurance to provide a basis for licensing."

Senator RIBICOFF. Well, the present legislation provides NEC regulation be limited to activities late in the development process, when the commercial feasibility, commercial reactors has been demonstrated.

Is this wise?

REACTOR REGULATION

As I listen to your testimony, from the standpoint of public health and safety, should NEC have authority to regulate reactors at the early stages of ERDA's in-house research and development?

Mr. FORD. Well, it seems to me that, to put the question in concrete terms, the principal thing that is being developed is the breeder reactor. And the question in that context would be, should NEC have some responsibility now for the safety of the breeder reactor? And I think the answer to that is definitely yes.

Senator RIBICOFF. And that goes to existing and future uranium enrichment plants, nuclear fuel reprocessing facilities?

In other words, I am trying to get your point of view. You do not want to shut this off completely? You feel there is a place for nuclear energy? You are concerned with what has been done and what is being done? Where can you continue the process and, at the same time, get as much safety assurance that you can possibly receive?

Mr. FORD. Well, I think that you have—you asked a moment ago about who was going to make the decision as to whether they are safe or not. And as I mentioned, this, ideally, should be done by a technically competent group with no bias one way or the other.

Senator RIBICOFF. Well, you questioned the NEC's qualifications to do this. And if you do, who should do it?

Mr. FORD. Well, I think at the moment I do question NEC because it is simply the AEC regulatory staff, the very same group that has been suppressing these critical safety problems, is the group that is named NEC, according to this legislation. I think that what has to take place under the present circumstances is recognition of the fact that institutions that have been set up have failed to develop nuclear power in an adequately safe manner.

Senator RIBICOFF. But who should do it?

CONGRESSIONAL OVERVIEW

Mr. FORD. Well, I think at this point in time, the Congress has to review the work product of the AEC, review the question of nuclear safety, and take it out of the hands of this agency, and decide whether at the present time we have a reactor safety crisis and, if so, what action should be taken. I mean for the long run, I mean a completely different type of agency with different personnel is obviously what is required.

And we can document, if you would like, the people who made the decision to suppress these safety studies, the people who have been censoring AEC reports. These people are still very much in charge.

Senator RIBICOFF. Well, I think you should. I think there is an obligation to put that on the record.

But, now, the Joint Congressional Committee on Atomic Energy, have they not been using their oversight function to go into the factors you are talking about?

There are many capable men in the Senate and the House, dedicated men. What have they been doing?

Mr. FORD. Well, we have been trying to communicate with the Joint Committee on Atomic Energy for several years now. As you may have heard, they held hearings after great delay early this fall, in September, on the question of nuclear safety. Only AEC people were there as witnesses.

We wrote to the joint committee, and several other groups have written to the joint committee, suggesting essentially this, that at the safety hearings that they hold, they should not simply listen to AEC management. We said that there were a large number of senior scientists and engineers in the AEC who did not believe that the AEC's position on the safety of nuclear powerplants was technically defensible. We gave the joint committee the names of these individuals, their addresses and so forth, and suggested that the critical element of their inquiry into reactor safety should be a hearing in which these, the principal experts on emergency cooling and other safety issues, be before them. And the joint committee has not responded to our letters. And, of course, when the safety hearings were held, the joint committee did not call any of these people as witnesses.

NEC INDEPENDENT OVERVIEW

Senator RIBICOFF. Well, how do you see NEC being structured to assure an independent overview? How would you do that?

Mr. FORD. Well, I think what has to be developed is, first of all, a substantial personnel change. I think it is simply not sensible to hand this problem, recognizing it as such, back to the AEC for resolution. The people who have made the decisions which have now been subject to criticism by the scientific community at large simply cannot be put back in charge.

STRUCTURAL SAFEGUARDS

Senator RIBICOFF. But what structural safeguards could you put in the legislation to protect the public?

Mr. Ford. Well, I think one of the most important structural safeguards would be those insuring complete openness in the type of technical reviews that are performed. And, for example, the AEC has an Advisory Committee on Reactor Safeguards. It is a committee of relatively prestigious people. It has great expertise. It has a staff of 70 consultants on various aspects of reactor safety, and it has operated in virtual secrecy for the last 15 years. It has never made public a technical report on any aspect of reactor safety. It writes a vague, two- or three-page letter that states that, if "due consideration" is given to the outstanding safety problems—whatever that means—then there is "reasonable assurance"—whatever that means—that plants can operate without "undue risk"—whatever that means—to public health and safety.

So that one of the problems we face is simply the various problems that are uncovered in the course of technical review inside the AEC are secreted within these committees. They made certain cosmetic changes. When this committee meets now, for example, under the Federal Advisory Committees Act, the public can come in and attend those sessions that the industry already had previously attended. I mean, when a utility company comes in and tries to sell the Committee on its nuclear powerplant, the public can sit there and listen to the talk. When the AEC regulatory staff comes before the committee, the public can listen to this talk. But the public has been and continues to be denied access to all other aspects of committee operations. The committee's own analysis of these technical issues is not open to the public.

Senator Ribicoff. Are there any further military safeguards involved in this entire subject of nuclear energy reactors?

Mr. Ford. The Advisory Committee on Reactor Safeguards spends a very small fraction of its time reviewing reactors that are used producing materials for weapons. But, beyond that, this whole operation of the AEC regulatory staff and advisory committees is all completely divorced, to my knowledge, from anything having to do with the weapons program.

But I think eliminating the secrecy of the AEC and of these committees in a statutory way, insisting on full and complete disclosure by these committees, would do a great deal for the long run to improve the regulation. But the problem we face at the moment is that it is one thing to talk about how we should continue to license nuclear powerplants; our problem at the moment is that the particular type of reactors that have been designed in a particular way, they have been designed and researched in the inadequate way that they have been researched, are now operating in the United States and many more are proposed.

And it is not as if we are in a position of just improving the administrative structure. There are substantive safety problems of the greatest urgency that are outstanding, and that is why I say that the matter falls to the Congress for some type of resolution. The AEC is willing to gamble, as I mentioned before, that the accident will not happen before they get the safety systems developed or perfected. They are willing to gamble, and I think that that is not an appropriate move for the country in general.

And I think that we have—for example, if you take the waste disposal question—I mean, we have a situation that I think can fairly be described as an emergency. The AEC is storing large quantities of radioactive wastes today in a supremely careless manner.

RADIOACTIVE WASTE LEAKED

Let me document this precisely. In June of this year, it was discovered that 115,000 gallons of high-level radioactive waste leaked out of a tank in the AEC's waste storage facility in Hanford, Wash.

Senator RIBICOFF. Where? Hanford, Wash.?

Mr. FORD. Yes.

The AEC's investigation of this revealed, first, that the tank had been leaking for several weeks; secondly, that no automatic alarm system alerted anyone of the leak. I note that any freshmen engineer at MIT could design for you an automatic alarm system that would tell you when the level of a liquid in a tank was falling below a certain set point; however, no automatic alarm system was installed. The management in charge of the storage facility did not review the monitoring reports. Once a week, someone went around to the tank and read an indicator that showed what the liquid level was in the tank, but no one bothered to compare the liquid level for 2 weeks, which would have shown that the tank was leaking. There was no preventive maintenance applied to the monitoring equipment, and persons with responsibilities for overseeing storage of these waste materials had no formal training to assist them in the execution of their responsibilities.

COULD RADIOACTIVE MATERIAL BE STOLEN?

Senator RIBICOFF. Could this radioactive material be stolen?

Mr. FORD. Well, that is another concern. It would not be profitable to anyone in particular to steal this type of radioactive material. What would be profitable for someone to steal would be the material from which nuclear weapons can be made. I should emphasize——

Senator RIBICOFF. This radioactive material that leaked, contains a potential danger to man, does it not?

Mr. FORD. It does, indeed.

Senator RIBICOFF. So, if you can highjack planes to threaten people or policies, could you highjack radioactive material?

Mr. FORD. Yes.

I simply wanted to suggest that if someone wanted to highjack radioactive material, they would not take the type involved in the Hanford leak. There is other, much more potent material, that they would steal.

Reactors, as you know, cannot explode like a bomb; they do not have the right type of material in them. However, as a byproduct, one of the waste products is plutonium, which is the material for our nuclear warheads. Each reactor produces an appreciable quantity of plutonium every year. The plutonium is separated from the other waste materials inside of the reactor. And by the year 2000, if the nuclear program goes ahead as it is proposed, we will be producing about 88 tons of plutonium a year.

Now, what must be kept in mind is that plutonium is one of the most toxic substances known to man. On a weight basis, it compares with botulism. I mean, a quantity of plutonium the size of a grain of pollen, if it were inhaled, is sufficient to give a man lung cancer. The amount of plutonium you could put in this glass is enough to create widespread injury to man. In addition, plutonium is a material from which nuclear weapons can be made. But even if the highjacker or terrorist did not make a nuclear weapon out of it, he still had an immensely toxic material that could be used for the purposes of blackmail.

We have reviewed the procedures that the AEC has applied to the handling of these radioactive wastes and the handling of plutonium. And, basically, up until a few months ago, if you wanted to ship plutonium, you would simply get on the phone and you would call up Schultz's Trucking and you would say, "I would like to send plutonium to Chattanooga," where it would catch a Delta jet some place. That is the frightening way that this special material was handled.

And we have the greatest anxiety that since this material is so potent in such small quantities that it will, in fact, be diverted and used by someone in our troubled times for bad purposes.

Senator Ribicoff. Let me go back to some basics.

Would your group advocate the shutting down now of all nuclear energy plants.

Mr. Ford. No. As I said before——

Senator Ribicoff. I know. But you do not propose that?

Mr. Ford. We do not.

Senator Ribicoff. You are concerned about safeguards to health and safety all along the line, the wastes, how the plants are operated, the safeguards, what happens in the research, what happens in methods and technology.

LEGISLATIVE SAFEGUARDS

How do you write into this legislation as many safeguard guarantees as we can find?

Mr. Ford. Well, what I have been trying to suggest, Senator, is that the legislation before the committee does not address the issue. We have a present crisis: nuclear powerplants that have pronounced safety problems. But all this legislation provides for is a renaming of the organization that now licenses nuclear powerplants. It does not address the imminent problems that we have.

I think that I would not be prepared to propose a comprehensive legislative program for dealing with nuclear power. Our expertise is in the technical studies of its underlying problems, and we can more or less present them before people with appropriate skills such as this committee and its staff, but we are not the designers of legislation ourselves.

But it would seem to me that the principal components of this legislation should be something like the following. First of all, the Nuclear Energy Commission should be established, a Nuclear Energy Commission.

Senator Ribicoff. So you are dividing it. You are for the Nuclear Energy Commission, is that right?

Mr. Ford. I am for that, I think, from an administrative point of view.

Senator RIBICOFF. All right.

Tell me what you do not like about that setup, or what bothers you about that setup?

Mr. FORD. Well, what bothers me about the setup is simply that it is a means just for continuing without any overhaul or review of the licensing of plants with these tremendous safety problems. It takes the same people who have, in our judgment, performed quite badly and simply says to them that you are going to have continuing powers in this area.

Senator RIBICOFF. All right.

Where are we going to get the people who can overview those individuals who you feel have failed in the past?

Where do you get that group, and how do you set them up in this apparatus?

Mr. FORD. Well, I think that a community of scientists at large—there is a large number of scientists and engineers. I think in the same manner in which executives are appointed, managers are appointed, that people who have independence from the nuclear industry and from the nuclear program in the past can be set up as the reviewers.

Senator RIBICOFF. But there is a group of advisers now who you feel have not been doing their job?

Mr. FORD. Well, I think that the advisers, for all I know, have been doing a splendid job. Our problem is that the AEC management has ignored the advice of its own scientists, of its own advisory committee, this secret advisory committee.

Senator RIBICOFF. Yes. But there has been given to you many of these reports and many of these analyses. The advisory group of scientists and engineers are not men and women on the payroll of the Atomic Energy Commission. These are men who are in the universities and engineering firms around the country. Is that right?

AEC CONSULTANTS

Mr. FORD. But they work halftime for the AEC as consultants.

Senator RIBICOFF. They are consultants, but they are men and women that you know, that you socialize with, that you work with at the universities and firms.

Do they talk to you about this problem? I do not mean you personally, but to you and other men who are of this concerned scientific group?

Mr. FORD. The members of the AEC's advisory committee have refused in all instances to talk to us about the substance of reactor safety. We have submitted to the Advisory Committee on Reactor Safety numerous letters asking them for their technical views of the various outstanding safety problems. We have met individuals from the committee on various occasions and have tried to ask them for their views on critical safety issues, and they have refused on all of these occasions to answer any questions.

I wrote a letter to them—one of the first things I did when I became involved in studies of nuclear power—asking for an interpretation of one of their brief little letters, and I got a call back from Mr. Fraley who is secretary to the advisory committee, telling me that "the Advisory Committee on Safeguards does not clarify itself."

Senator RIBICOFF. Who is chairman of that advisory committee?

Mr. FORD. At the moment, the chairman is a man named Harold Mangelsdorf.

Senator RIBICOFF. Where is he located?

Mr. FORD. His office is at 1717 H Street, Washington,

Senator RIBICOFF. In other words, that is a full-time job, the chairmanship?

Mr. FORD. I believe the chairmanship is a full-time job. The other members, as you suggested, are mostly academics. David Okrent from UCLA, Edward Mason from MIT, Dade Moeller from Harvard School of Public Health, people like that.

Senator RIBICOFF. Do you feel that the men you are talking about have abdicated their public responsibility?

Mr. FORD. I have managed to try and discuss that matter with one member of the committee, and I asked him how did he think that the AEC could continue to license nuclear powerplants with all of the unresolved safety problems that his own committee had identified. And he stated that the committee had made an overall judgment that, all things considered, the risk was acceptable in light of all the various alternatives.

And I tried to point out to him that, under the statutory provisions setting up this committee, it does not give the committee the responsibility for making this overall political judgment on whether the risks are acceptable. It simply instructs the committee to report to the AEC on the hazards associated with nuclear power operation.

In those terms, I think the committee has failed, without any doubt, to perform that responsibility. They have never issued a meaningful technical report on the safety problems.

RESPECTABILITY OF UNION OF CONCERNED SCIENTISTS

Senator RIBICOFF. Well, let me ask a practical question. How does the Atomic Energy Commission look upon the Union of Concerned Scientists?

Do they respect you? Do they think you are crackpots, or how do they react to you?

When you try to talk to them, do they listen to you? Have you ever sat down with Mr. Mangelsdorf or Dixy Lee Ray to discuss these problems? Have they ever sat down and discussed these with you?

Mr. FORD. Well, I think we have worked quite closely, although quite secretly, with several of the agency's scientists. We have communicated the results of their research to the public, and they feel that we have done so in a correct way. They also respect our own technical studies on safety.

Now, as far as the AEC's general regard of our group, the overview on nuclear power that we are filing today with the committee has an appendix which includes comments by scientists and engineers on the work of the Union of Concerned Scientists the AEC's own scientists wrote, in an internal memo as following:

> The three members of the Union of Concerned Scientists met with members of the Oak Ridge National Laboratory staff. We felt that the technical publications of this group, as well as their professional integrity, justified a meeting with them.
>
> The three members of the Union of Concerned Scientists who visited here appeared to be well educated and dedicated people. According to them, they had not received satisfactory answers from either the utility or the vendor in the case

of the Pilgrim reactor as to some of the issues raised in the papers. [These are our technical papers criticizing ractor safety.] So they felt compelled to undertake the intervening role.

In pursuing this role, they have become intimately familiar with the relevant published literature, and their experience has led them to examine the situation closely, and they have become aware of various deficiencies in the case for emergency cooling system performance.

So we find among the AEC's own scientists——

Senator RIBICOFF. Have you ever sat down with the chairman of the advisory committee or Dixy Lee Ray?

Mr. FORD. I have not sat down with either of those two people. We have difficulty, since we are involved in litigation and so forth, with the rules governing ex parte communication, so far as talking to Chairman Ray is concerned. But I have talked in the last year with three of the members of the Advisory Committee on Reactor Safeguards, and in two of those cases they refused to say virtually anything.

In one of those cases, one of the members explained to me how the committee believed that, even though the safety problems were unresolved, they thought there was a small enough risk, such that for a small number of reactors, the program could go ahead. Although he stated if we had a large number of reactors like the ones we have now, the advisory committee would be opposed to that.

LEGISLATING SAFEGUARDS

Senator RIBICOFF. You see, we know you have to do research on alternate sources of energy. We do have an obligation to make sure that all possible health and safety safeguards are protected.

We would like for the mechanism to be independent to assure the Congress, the President, and the American people, that what is being done is being done with all these safeguards in mind.

I do not have the technological expertise to understand the health and safety problems involved here. And yet I can see that they are with us.

Where can we put into this legislation an independent source to give the Congress, the President, and the public assurance that everything possible is being done?

Mr. FORD. The NEC, as it is described here, includes a regulatory organization and a general provision that this NEC may be able to conduct whatever research they feel is necessary on the question of nuclear safety. And one thought in this area might be simply to separate those two functions: to set up a judicial review organization that, as an administrative agency, could decide on nuclear powerplant licensing, that will have its advisory committee, that will have a regulatory staff to review the licensing applications, and to make a formal position on that licensing application; but to have independent of that organization a separate agency, which is simply the reactor safety research administration, which simply conducts technical research and makes these research studies available to anyone. They would make them available to the Nuclear Energy Commission; they would make their personnel available to citizen groups as witnesses that can be called in reactor licensing proceedings.

REVIEW OF LICENSING PROCEEDINGS

I think that, in addition, to insure a reactor licensing process of some integrity, that major repairs could be effected in the licensing proceedings themselves. There has recently been a major review of AEC licensing proceedings done here at George Washington University under a grant from the National Science Foundation, and it reported, for example, on the over weening bias on the entire licensing process, that the citizen groups were, by and large, completely frustrated in any attempt to exercise adjudicatory rights.

For example, if I live next to a nuclear powerplant, a proposed nuclear powerplant, and I want to oppose its licensing, well, one thing I might do is study the scientific literature. I might find, for example, that in such and such an Atomic Energy Commission laboratory, there are people who have certain beliefs which I feel are material to the hearing, which would influence the decision and should influence the decision of reactor licensing.

Well, at the moment, Atomic Energy Commission rules of practice governing licensing prohibit me from getting a subpena for any of these technical experts. The Atomic Energy Commission has taken the position that it alone can decide what Atomic Energy Commission employees appear as witnesses in licensing proceedings.

And I think one clear example of the AEC's overreaching itself is the fact that there were, in some of the licensing hearings, contractors to the AEC whose personnel were requested on an intervener's behalf, and the AEC appeal board was forced to allow the interveners the right to subpena these contractor employees. Then the AEC turned around and changed its regulations to define the term "employee" to include contractor employees. The attempt to prevent criticism of reactor safety is manifest in this type of administrative maneuver.

So that you have the situation where citizen groups were, by a very active and vigorous AEC Office of the General Counsel, prohibited from getting witnesses who can present information that is quite germane to the licensing proceeding.

Senator RIBICOFF. Now, as I look at the setup of ERDA, you have an Assistant Administrator for Environment Safety and Conservation, and then separate Assistant Administrators for fossil energy, nuclear energy, advanced energy systems, and national security. One of the functions that each of these Assistant Administrators will be responsible for is environmental safety and conservation. All these functions are supposed to fuse together; but you do not have much faith in the possibility of doing that from past experience; that is, that all the divisions headed by the Assistant Secretaries would all react generally to what the overall policy of the top management is.

Mr. FORD. Well, I think that would be my expectation. When I first became involved in these studies of nuclear power I simply had no suspicion whatsoever that scientific and technical information was being deliberately manipulated and suppressed by the AEC. I mean, major research programs in this country dealing with nuclear powerplant safety have been terminated by administrative fiat inside the AEC for the reason that the results from this safety research program were showing that there were reactor safety problems where the industry had assured that reactor safety problems did not exist.

The management of the Atomic Energy Commission, for example has censored the reports from AEC's safety laboratories. I can refer you to sworn testimony by a man whose reports were so treated.

The AEC has attempted—people who are presently management level people in the AEC—they have attempted to censor the results of research reports that AEC scientists wanted to present before professional society meetings.

SUPPRESSED AEC REPORTS

Senator RIBICOFF. Do you have a summary or do you have copies of the reports that have been suppressed?

Mr. FORD. We have some, but in some cases the report does not exist. We have forced a lot of reports that were suppressed to have to be made public. I have several thousand pages of those which can certainly be made available.

I can tell you, for example, just to give some concreteness to this discussion, of the type of material that has been suppressed. In 1971 the AEC wanted to reorganize its reactor safety research program. They asked their principal consultants on reactor safety to do a status report that told where we were in our understanding of some of these critical problems. The report was done under the leadership of George Brockett, who was one of the AEC's leading experts in reactor safety. He presented the results of his study in a major report. There was a summary table in the report that listed 28 areas where you needed technical information to analyze emergency cooling system performance; and it gave a status report for each of the 28 areas in the table.

And the status report, reading out of the column, read, "Unverified, inadequate, incomplete, uncertain, imprecise," etc. In seven of the critical areas there simply was no status report because there was no information at all in those areas.

Now, this particular report was done under contract to the AEC's Division of Reactor Development and Technology, which oversaw the safety research. And this Division of Reactor Development and Technology is what will evolve in this present legislation into the backbone of ERDA.

The Division of Reactor Development and Technology did not make this report public. Moreover, the Division of Reactor Development and Technology did not make this report available to the Atomic Energy Commission licensing staff. The AEC licensing staff saw the report for the first time, when, after it had been leaked to us, we made the report public.

Information critical to reactor safety was being suppressed.

Now, there was a public hearing last year in which, for the first time, we forced the AEC to allow us to crossexamine their own safety experts; and what has developed out of that hearing is that the people who are the principal critics of AEC's safety policy have by and large been removed from their positions.

This man whom I quoted earlier was so treated. This man, Dr. Morris Rosen, was in charge of emergency cooling systems analysis. But shortly after he wrote a memorandum opposing AEC policy, he was removed from his position.

Senator RIBICOFF. What happened to him?

Was he fired from the AEC?

OUTSPOKEN AEC STAFF REMOVED

Mr. Ford. He was put into a technical advisory office where he no longer had any responsibility over emergency cooling, and after several months in that office he resigned, and he now works in Seoul, Korea, for the International Atomic Energy Agency.

Mr. J. Curtis Haire, for example, who is in charge of the Agency's principal research effort in emergency cooling, he testified at pages 7591 through 7593 of the AEC's hearing record (Docket RM 50–1) that the AEC was censoring reports from his safety research program to prevent Congress from raising embarrassing questions on nuclear power.

Mr. Haire was removed from his position. I was out in the laboratory subsequent to his removal, and I asked him whether he was being censored any more; and he said, "No, I am not. I am not allowed to write anything any more." He was completely removed from the safety research program.

Oak Ridge National Laboratory had a major safety research program and a Nuclear Safety Division. The head of the nuclear safety program wrote to the AEC Director of Regulation at the same time they had this public hearing; and he said in his letter, a 30-page letter, that it was appropriate for him to give comments on the validity of these AEC safety regulations now that a public hearing was scheduled. And he indicated on the letterhead that this letter was in reference to the AEC's docket on emergency cooling; and thus, it should have been filed in the public document room.

What he said in the letter was that the people in his laboratory do not believe that the AEC's safety regulations provided reasonable protection for the public health and safety.

The AEC did not docket this letter as it was supposed to. It was returned to the Oak Ridge National Laboratory and not made public. It was made public by us. It was leaked to us, and we put it into the hearing record. And the nuclear safety program man who was in charge of it is no longer in charge of it. The program does not exist. The critical research program that they had undertaken to show whether or not certain phenomena would oppose the operation of the safety system—that program was completely terminated.

I think these examples show something about the AEC management. And I simply cannot see, with this information in front of us in the table, how one in good conscience can simply say that these same people will become the Nuclear Energy Commission and the nuclear program will go on ahead.

I mean, it is very difficult to believe, I think, that nuclear power with all of its great hazards would have been developed with anything less than the greatest care and diligence. I mean, the potential for such large accidents is so apparent.

But nevertheless, however nonintuitive this set of circumstances is, that is the circumstance; and remedial action has to be taken to remedy this circumstance. It is, at least not in my judgment, found in the legislation under consideration.

Senator Percy. Mr. Ford, I would like to ask you specifically about the legislation, if you do not mind the interruption. I am continually concerned about how you operate under emergency conditions particularly how much power you do give and how you short circuit some of

the procedures that have been established when you were not under those conditions.

EMERGENCY POWERS

I would like to ask for your judgment about the relationship between the emergency powers of the Federal Energy Administration as proposed in the legislation and the requirements for protecting the public safety and the environment.

In trying to cope with the immediate energy shortages, specifically should the Federal Energy Administration have the specific authority to temporarily suspend regulations of either the EPA on air quality or the AEC on nuclear powerplants licensing?

Mr. FORD. Well, I think that in terms of the back of the envelope cost benefit analysis that is being done, in terms of the price we pay, of not having adequate supplies of oil; and the benefits, therefore, we would gain by using dirty fuel, I think that it certainly would seem appropriate to provide for the authority to suspend temporarily air quality regulations.

But I think that this has to be done in such a way that it gives the industry no incentive to count on the suspension of these regulations every time bad planning and pricing policy create an energy crisis.

DISINCENTIVE

I think at the same time, though, when utilities are allowed to burn high sulfur coal, that they should be taxed for the effluent that that will create. Moreover, the price structures that they are allowed to use for the sale of that electricity should not be such as to encourage the consumption of electricity. And in this way you can say to the utility companies, yes, for the winter months of 1973–74 you can burn high sulfur coal or oil, but you have to pay a tax on it. You cannot give people an incentive to use it.

Senator PERCY. In other words, there should be an accompanying disincentive for continued use beyond the emergency period?

Mr. FORD. Right. A disincentive for continued use.

Senator PERCY. But how does that apply to safety and the licensing of a nuclear powerplant?

How do you have a disincentive once you have licensed a plant that may or may not be safe to continue?

Mr. FORD. Well, I think the fact of the matter is that nuclear powerplants are not going to be able to play any role in extricating ourselves from this winter's energy problem. As a matter of fact, one of the problems, one of the components of the energy crisis at the moment is that the nuclear powerplants are performing in such an unreliable way that that is part of the energy problem.

NUCLEAR POWERPLANTS OPERATING AT HALF POWER

I mean, consider the case of New England. We have five large nuclear powerplants, and one would think that we need every bit of power that they can produce. Well, unfortunately, this fall it was discovered that there was some unsuspected safety problems affecting a couple of these plants. One of them had to be shut down. I believe it is now operating, but not at full power because it has another safety

problem. One of them, Boston Edison's large plant is only allowed to operate at 50 percent power because of suspected structural damage in the reactor core. Another one of the plants, the Millstone plant in Connecticut, has not produced power in something like 10 out of the last 12 months because of an accumulation of safety problems there.

So I think at the moment nuclear plants are being restricted quite seriously in operations because of the safety problems. And it simply is not practical to speak of their being brought into service right away.

NUCLEAR ACCIDENT NEAR WESTERN WHITE HOUSE

And President Nixon's neighborhood nuclear powerplant in California, a few thousand yards from the Western White House, experienced a very serious accident on October 21. I do not think the President was aware of this when, in his speech at Disney World, he talked about how even he lived next to a nuclear plant. I mean, the accident occurred. It was aggravated seriously by an operating——

Senator PERCY. When did the accident occur?

Mr. FORD. October 21, 1973.

Senator PERCY. And when was the President's speech?

Mr. FORD. The President's speech was sometime during November.

Senator PERCY. And how serious was the accident?

Mr. FORD. Well, no one was killed or injured, but the accident revealed a number of substantial weaknesses in the design of the plant. It was sort of an index of the plant's safety. The turbine threw a blade and the condenser was damaged. The operator made an error in trying to shut down the reactor. The operator made a subsequent error and the emergency cooling system started to come into operation but performed in a defective manner. The emergency cooling water line started vibrating and loosened the support hangars and damaged the valves. And so it exposed a large number of substantial safety problems in that reactor.

Senator PERCY. Mr. Ford, you are an economist essentially, and Dr. Kendall is a nuclear higher energy physicist. He did not come with you today?

Mr. FORD. No. We were both planning to testify before this committee last week, but when the hearing was rescheduled late last week for today Dr. Kendall was not able to come because of previous appointments.

Senator PERCY. But he stands behind this testimony of yours?

Mr. FORD. Oh, yes.

Senator PERCY. And could you tell us what are your respective positions in the Union of Concerned Scientists?

APPEARING FOR UNION OF CONCERNED SCIENTISTS

Mr. FORD. I work fulltime for the Union of Concerned Scientists in doing reactor safety studies.

Senator PERCY. What is your title on the staff?

Mr. FORD. I am simply on the staff.

Senator PERCY. But you are officially appearing on behalf of the union?

Mr. FORD. That is correct.

Senator PERCY. How broadly based is your membership? You are based in Cambridge, but do you have a national membership?

Mr. FORD. We have worked in the past with scientists at different institutions around the country; but the membership is basically limited to the Cambridge area.

Senator PERCY. So you do not have members from Oregon or from other nuclear installations and laboratories?

Mr. FORD. We have worked quietly with a substantial number of AEC people helping us do various studies on reactor safety at various AEC installations; so I guess there are outposts in those areas.

Senator PERCY. I think you perform, obviously, a very, very valuable service. And I think we are very grateful for your testimony today and for the concerns that you have expressed.

Both the chairman and myself have worked in some of the areas that are related to your concerns. I know we got into the disposal of poison gas problem, and you mentioned the disposal of 115,000 gallons of high level radioactive waste that has leaked.

I put the legislation in that became law that we were not going to accept just a Federal Executive order and regulation on disposal. We wanted to build it into the law, and we tried to plug all these loopholes and concerns that we can.

We are grateful for what I consider to be the Ralph Nader of the nuclear field and your group.

I would like, Mr. Chairman, because of the concerns expressed, to take this testimony and submit it to the heads of some of our national laboratories, at Oregon, Batavia, Dr. Wilson, some of the past Commissioners of the AEC who are themselves—Commissioner Bocher of Caltech—to get their response. I think it might get us a balanced picture.

What kind of reaction do you think if we picked a good, broad cross section group, what kind of a response do you think we will get? And I might send it to a few people in the industry, certainly Commonwealth Edison, and possibly J. Ward Harris in Chicago, Commonwealth Edison there, just to get as balanced an impression as we can of the concerns that are mentioned.

Mr. FORD. Well, we can, if you like, submit the names of several dozen scientists in the United States and around the world who share our belief in the existence of very serious unresolved reactor safety problems.

Senator PERCY. Well, we would like names of some of those, and then our own staff can, I think, develop some that you might not have been in contact with.

But I just wanted to express appreciation for your appearance here and for your contribution.

Mr. FORD. Thank you.

Senator RIBICOFF. We appreciate that, too.

Without objection, what Mr. Percy has asked will be ordered.

It becomes very obvious from your testimony that we are dealing in an emergency basis for the Federal Energy Administration and Energy Research and Development Administration. I do not imagine, Senator Percy, that whatever we pass during the next week is going to be the final answer. It becomes obvious that these are stopgap measures, and that you will have to proceed to create a Department of Energy and National Resources as a permanent organization. And many of the

problems that you raise must be provided for. Without question, it would seem that there should be some independent group or committee, whatever you call it, to work in the field of safety all across the board as we start developing alternate sources of energy.

I do appreciate what you have said; I also think the AEC should be given an opportunity to respond to your criticisms, including these charges of secrecy and suppression of data.

[The following material was subsequently received for the record:]

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., January 14, 1974.

Hon. ABRAHAM A. RIBICOFF,
Chairman, Subcommittee on Reorganization, Research and International Organization, Committee on Government Operations, U.S. Senate.

DEAR SENATOR RIBICOFF: The testimony of Dr. Daniel Ford on Senate 2744 delivered to The Subcommittee on Reorganization, Research and International Organization of the Committee on Government Operations has been brought to my attention. In view of the several general allegations made by Dr. Ford about the AEC, we wish to submit this letter with its enclosures for the record.

An unfortunate and regressive aspect of the controversy over nuclear power in the past decade has been the fact that all too often extraneous, irrelevant, and in some cases, deliberately misleading issues have been injected into the public arena. In some cases the adequacy and safety of nuclear technology is attacked through such issues as Commission procedures; the alleged stifling of dissent within the Commission's technical body; the nondisclosure of documents which somehow, if exposed to public view, would "do in" the technology; and through the notion that the AEC has been engaged in a program of foisting an unsafe technology upon an unsuspecting public. Issues of these types appear to be the basis of a number of Dr. Ford's allegations in testimony before the Subcommittee.

His charges fall into two major categories and several lesser ones. (1) He believes nuclear plants are unsafe and unreliable, but that safe reactors could be designed. The problem is that AEC has not been forthcoming on the major safety issues. This leads to his second major charge that (2) AEC has been engaged in a massive cover-up campaign. AEC has suppressed and ignored adverse views by its own scientists who contend that safety systems will not work. Alleged suppression of the Brockett report and the "secret" 1965 Brookhaven study are cited as examples. Furthermore, the Advisory Committee for Reactor Safeguards has not provided adequate public information and participation. The above allegations net out to the position that regulatory operations and safety issues are shrouded in secrecy.

His lesser allegations include that (3) major research programs were terminated by administrative fiat when sagety problems showed up; (4) nuclear wastes are handled unsafely, leading to an increased possibility of plutonium theft; (5) the breeder will not breed as well as had been hoped; and (6) the Joint Committee on Atomic Energy has refused to hold open hearings on reactor safety issues.

Let me briefly address these issues as raised.

THE SAFETY AND RELIABILITY OF NUCLEAR PLANTS

Dr. Ford in his testimony cites shutdowns, malfunctions and "accidents" at nuclear power plants to indicate lack of safety and general unreliability.

The AEC believes that nuclear power plants which are designed, constructed and operated in accordance with AEC regulations and requirements present an acceptable risk to the health and safety of the public and are licensable. This does not mean that there are absolutely no problems with respect to the safety of operating nuclear power plants and that all risk has been eliminated. The fact is that we do not live in a riskless society and there are many sources of this public risk. Nevertheless, the risk to the public health and safety from reactor operations is so extremely low that it is acceptable.

The principal bases for our judgment concerning the safety of nuclear power plants are the stringent safety and quality standards imposed by our regulations. These require extensive back-up systems, an extensive quality assurance program, and the comprehensive safety reviews of nuclear power plant design, construction and operation conducted by the AEC Regulatory staff and the ACRS before plant construction and operations can be authorized. We have had to date over 180 reactor-years of operations of licensed nuclear power plants without a single instance of radiological injury to the public.

The AEC has not hesitated to withhold its approval of proposed plant sites or design features when either of these two important aspects of reactor safety do not meet our stringent requirements. Such was the case with two nuclear power plants proposed for construction near Mendocino, California, last year. Also, the AEC has required reductions in the power levels of operating nuclear power plants when necessary to assure that our safety criteria relating to plant operations are sonservatively satisfied. As an example, the AEC Director of Regulation issued orders covering 10 operating reactors on August 24, 1973 requiring a reduction in their maximum authorized power levels or restriction of operating procedures. We are prepared to take any steps necessary to ensure safe operations. At the same time, we believe these power plants have demonstrated their reliability.

The reliability of nuclear power plants is addressed in the enclosure, "Availability of Nuclear Plants." The studies show that nuclear plants are at least as reliable as fossil plants. Dr. Ford cites several abnormal occurrences to demonstrate that nuclear plants have high unreliability and low safety. The identification of these occurrences demonstrates (1) that programs do exist to detect these abnormal occurrences and (2) the value of such programs since corrections are made as a result of them. All occurrences were reported by the licensees and made part of the public record. What is often missed, is that many of these problems have occurred in non-nuclear systems. They still must be reported because they are part of a nuclear plant. Comparable information is not provided for fossil fuel plants because they are not required to report operating problems. I am enclosing two short reports, "Abnormal Occurrences At Nuclear Power Plants" and "Occurrences At Specific Plants" to assist in placing some of Dr. Ford's views in a proper context.

The AEC is constantly striving for continuation of the perfect safety record attached to nuclear power. In doing so it consciously assumes a stance on the side of safety and caution, realizing that the industry is new and growing, and that public acceptance must be earned. Dr. Ford's arguments fly in the face of the perfect safety record that has been achieved. In the absence of accidents that have injured the public he has had to manufacture the emotional stance he has taken not from injuries but from the evidences of concern expressed by the AEC and the very measures we have taken to protect the public that have resulted in this good safety record.

THE SUPPRESSION OF INFORMATION

The policy of the AEC relative to information available to the public on reactor safety is one of complete openness. The secrecy charge cannot withstand scrutiny. All reactor safety matters are made freely available. In addition, as a deliberate and considered policy, the Commission has gone far beyond even the broad mandates of the Freedom of Information Act. As an example, in the very proceeding referred to by Dr. Ford concerning emergency core cooling systems, the Regulatory staff threw open its internal files and even went so far as to provide earlier drafts of its prepared testimony. Beyond even that, the staff produced for the public record all of the confidential views of its laboratory advisors, including those views which differed from the staff's.

Estimates of the quantity of documents provided the participants in the ECCS proceedings run far in excess of 50,000 pages. Included within the documentation are shadings of technical opinion on various facets of the technical issues involved. Internal memoranda, properly privileged, were released as a matter of discretion. Drafts of drafts and similar materials far beyond the reach of the Freedom of Information Act or normal evidentiary disclosure were voluntarily provided, as were copies of all of the staff's consultants on its draft testimony. These comments included references to areas in which unanimity on technical matters does not exist.

The Brockett Report (Exhibit 1039), which was "leaked" to Dr. Ford and others and offered into evidence by them, was never relied on by the staff in formulating its position, nor was it ever requested by Dr. Ford's group. Had they requested the document, which was sorely outdated, the AEC would have readily provided it.

The public rulemaking hearing on emergency core cooling system (ECCS) criteria provided an extensive forum for public discussion of power reactor safety which extended over a period of nearly two years. It produced a transcript of 22,380 typewritten pages and several hundred exhibits, including an environmental statement as required by the National Environmental Policy Act. The Consoli-

dated National Intervenors (CNI), which Dr. Ford represented in this proceeding, produced a large portion of the record. This was certified to the Commission for use in the recently announced decision which modifies ECCS criteria.

THE WASH-740 REEXAMINATION OF 1964-65

Dr. Ford makes much of the "secret study" conducted at Brookhaven Nationa Laboratory (BNL) of the consequences of theoretical major accidents at nuclear reactors during 1964-65. Actually, this was an uncompleted study of which all pertinent documents, drafts, memoranda, notes and papers, internal or otherwise have been publicly released. The AEC has, contrary to the secrecy and suppression charge, followed the course of openness in making this study available. The documents released included rough drafts, working papers, internal memoranda, and various papers which bore on the general subject. The purpose of the study was to examine extreme reactor accidents, without regard for probability of occurrence, for use in considering the possible extension of Price-Anderson indemnification.

The AEC released this material knowing that among the papers were minutes of meetings at which some participants argued against publication of the results. We released also drafts of the technical papers which the Brookhaven scientists had prepared afterwards to be published openly with full concurrence by the AEC. It is unfortunate for all at this stage that the Brookhaven group did not arrive at a final draft they thought suitable for publication. We should note again that the 1965 Brookhaven study was not performed to define the consequences of a reactor accident, as Dr. Ford and his colleagues persist in saying. It was done to form an absolute upper bound to any results that could be imagined from any accident to a nuclear power plant. Little regard was given as to how unlikely the accidents might be. In fact, the study assumed conditions which cannot exist within AEC regulations. We do not permit locating a commercial reactor within a city. We also do not permit constructing a reactor without concrete containment around it and a building over it. But this study made all of those assumptions plus it presumed the simultaneous failure of all engineered safeguards. Although the biases in this study have been widely discussed and accepted within the scientific community, Dr. Ford continues to misrepresent the issue.

The Commission has announced that a new study is being performed to provide a realistic assessment of accidents. This study, estimated to cost about $2 million, has been in progress for about a year under the direction of Dr. Norman Rasmussen of the Massachusetts Institute of Technology. It will provide a more precise quantification of the probabilities and implications of nuclear accidents, using methods recently developed for predicting the reliability of the performance of individual plant components. The study, which also will include a comparison of the risk from nuclear accidents with some of the other technological risks that society currently is taking, will be completed this year and released to the public.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) ACTIVITIES

Dr. Ford has alleged that the ACRS has refused "in all instances" to talk with him or his representatives about the substance of nuclear reactor safety. The Committee's role in the regulatory process is that of an advisor to the Atomic Energy Commission. Its statutory responsibilities under the Atomic Energy Act are to review safety studies and license applications referred to it, to consider the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and to perform such other duties as the Commission may request. Consideration of reactor safety research needs is one such duty assigned the Committee. Committee advice provided the Commission is made available to the public, including Dr. Ford, in the form of written reports which are published by the Commission. The Committee is composed of several members, all of whom act as part-time advisors to the AEC, spending about 100 working days per year on their duties. They are all distinguished scientists who bring diverse backgrounds and viewpoints to bear.

Since September 1972, Dr. Ford, or groups wherein he is a key participant, have made nine requests of the Advisory Committee for Reactor Safeguards for information regarding the safety of nuclear plants. A number of these requests have involved a considerable quantity of information and have required considerable man-power to provide the response requested by Dr. Ford. For example, one such request involved 86 detailed interrogatories regarding the performance of emergency core cooling systems and another involved 76 detailed interrogatories regarding various aspects of reactor safety and the AEC regulatory process. The ACRS in every case, except the two most recent which are still under consideration, has provided a reasonable reply to Dr. Ford and his associates.

The two most recent requests, from the Union of Concerned Scientists and Mr. Ralph Nader, involve in excess of 30,000 pages of ACRS documents and records which will require considerable time and manpower to process.

The ACRS has been providing its reports to the public for sometime. For instance, since September 1972, when Dr. Ford first expressed an interest in ACRS matters, 34 reports on specific reactor projects and 19 such reports on various generic safety matters have been made public. This includes one report on the status of generic safety matters related to Light-Water Reactors (date December 18, 1972) which is currently being updated. It is also possible for Dr. Ford and other members of the public to provide input and keep themselves informed regarding the activities of the ACRS in accordance with the provisions of the Federal Advisory Committee Act. Since March 1973, the ACRS has held 43 Subcommittee meetings and 10 meetings of the full Committee which were open to members of the public. Committee procedures provide for consideration of written comments from members of the public, oral statements at ACRS meetings and attendance at ACRS meetings by members of the public. As best I can determine, Dr. Ford has never attended an ACRS meeting nor has he provided written or oral comments specifically for consideration by the Committee. I urge Dr. Ford to make use of these already available techniques for input and gathering of information rather than proposing that the ACRS direct its time and attention to the areas that he selects and in a manner suited to his particular desires.

INCREASING THE AVAILABILITY OF INFORMATION

The Commission is vigorously engaged in taking further steps to provide the facts for informed public debate of issues that often are complex and difficult to understand, even for experts. AEC believes that the public has the right to participate in regulation and to be kept currently informed. Among steps being taken to achieve both of these objectives are the following:

"In 1973, sessions of the AEC's Advisory Committee on Reactor Safeguards (ACRS) were opened to the public for the first time to hear presentations by license applicants and by the AEC Regulatory staff. This step was taken under the new Federal Advisory Committee Act. Further measures are under consideration to provide greater public access to ACRS documents.

"The Regulatory staff has adopted the practice of inviting intevenors and potential intervenors in individual licensing proceedings to meet informally with AEC staff. These meetings are held in a community near the proposed site or project at an early stage in the application review process. These forums have provided opportunities for the public to express its concerns to the AEC licensing staff for incorporation into both the safety and environmental reviews.

"The Commission has expanded its practice, adopted in 1972, of ordering public rulemaking hearings on Regulatory matters of widespread public interest and those issues which are generic to several or all reactors.

"In mid-1973, in order to assure that the public promptly receives the facts on incidents in licensee operations having significant public interest, the AEC adopted the practice of issuing public announcements on such occurrences independent of any licensee actions in this respect. The Regulatory staff follows a policy of openly evaluating problems in its inspection and enforcement program and making its findings available to all licensees, the industry, and the public.

"Additional steps are being taken to make more technical information routinely available to the public to assure maximum availability of documents containing safety-related material. Research and technical assistance documents will be made available in the Public Document Room for inspection and copying at the time they are submitted to the Regulatory staff. This will include reports on subjects common to more than one nuclear plant. In addition, a comprehensive guide is being prepared to assist in locating material in the Public Document Room, located at 1717 H Street, N.W., Washington, D.C.

"AEC now is considering changes in its policy and regulations for handling proprietary information in the Regulatory program, that is, data designated by an industrial firm as confidential in order to protect its competitive position in the market place. While AEC records and documents in licensing proceedings are routinely made available to the public, an exception is the disclosure of proprietary information which is consistent with the Freedom of Information Act. In any event, such data are made available to parties in a proceeding under protective arrangements."

Some people maintain that proprietary data may contain important information on safety aspects of nuclear facilities and that this should be freely available to

the public where it is a factor in a license decision, while others argue that protection of such information provides an incentive for safety research and development. The AEC has asked for public comments on possible alternatives to its present policy and regulations.

The Commission has been actively pursuing the precept that the public is entitled to all the information that can be provided regarding its Regulatory responsibilities for protecting public health and safety. This is clearly demonstrated in the licensing and regulation of power reactors. As the President noted in his April energy message, "The process of determining the safety and environmental acceptability of nuclear power plants is more vigorous and more open to public participation than for any comparable industrial enterprise."

Let me turn now to some of the lesser allegations raised by Dr. Ford.

REACTOR SAFETY RESEARCH PROGRAMS

Contrary to allegations made by Dr. Ford, the AEC has been expanding its research efforts in reactor safety areas. All major programs have been continued, but under the direction of a separate division within the AEC. This new division has provided increased focus on light water reactor safety problems and is actively expanding the current research. In addition, continuing emphasis is placed within the Division responsible for reactor development on developing safe systems. The AEC operating philosophy has always been that safety must be built into systems initially and continually improved.

HANDLING OF RADIOACTIVE MATERIAL

Dr. Ford's comments on the handling of plutonium and nuclear wastes are confused, at best. The handling of nuclear wastes and the handling and shipping of plutonium are, in fact, two different tasks. The wastes produced by reactors contain plutonium. It is not separated by the reactor. This can, in fact, only occur through subsequent processing. There is almost no chance anyone would attempt to steal these wastes to acquire plutonium because the wastes are kept in large containers which are very bulky and heavy. Furthermore, the processing of the wastes to retrieve the plutonium is complicated and requires special facilities. However, plutonium is shipped separately for use in other areas (such as for research or weapons.)

Dr. Ford was correct that the physical protection afforded to plutonium shipments by the nuclear industry in the past was less than now required, even though the amounts were relatively small and shipments relatively infrequent. The regulations met Department of Transportation requirements and were consistent with those afforded comparable items. The principal concern was directed towards safe containment. AEC's own shipments, even those moving via commercial carrier, have always been much better protected and were not as vulnerable as the nuclear industry shipments could have been. On November 6, 1973, the AEC published new regulations which upgraded the security protection for nuclear industry shipments. As a result, it now would be extremely difficult for someone to steal a shipment of plutonium. Those new regulations include such provisions as for: an escort vehicle; specially designed trucks; communication requirements; surveillance procedures; and special vehicle markings.

Dr. Ford also cited the leak of waste material from Tank 106T at Hanford as an example of defective procedures. Enclosed is background information on this waste leak. The AEC, in examining the causes of the leak determined that individuals had not in fact performed their responsibilities. Appropriate actions have been taken but on the positive side, it was aslo demonstrated that the storage site was sufficiently isolated to assure the public safety in the event of a leak. In fact, considerable information on the geology of these sites has been available for some time. The AEC purposely chose this area because the soil composition is such that it acts as a natural protective barrier between the tanks and the water table. There is a natural layer of caliche, a non-porous, concrete-like substance under the tank farm. The Environmental Protection Agency (EPA) conducted a review of the site and concluded the leakage of radioactive material from the 106T tank did not constitute a threat to the public in the foreseeable future (4 December 1973 letter to Mr. R. E. Hollingsworth, AEC, from W. D. Rowe, EPA).

THE LIQUID METAL FAST BREEDER REACTOR

Dr. Ford states that it is generally believed that breeder reactors have much more pronounced safety problems than the light water reactor. In another part

of his testimony, he implies that breeders have inherent problems that cannot be remedied. While it is correct that there are some safety considerations unique to each system, it is the assessment of the nuclear community that the advantages of the LMFBR (low pressure, coolant heat capacity, etc.) more than compensate in the safety analyses for its unique safety problem areas (sodium void coefficient, high power density). There is no doubt within the scientific community that LMFBR designs will give more than adequate assurance that public health and safety will be preserved under all circumstances, even in the highly unlikely event that a severe accident should occur. In addition, the LMFBR demonstration plant will be subjected to the careful regulatory review prior to its approval to be constructed and operated.

It is even more puzzling to find the statement, "The greatest secrecy has been provided by the AEC," following a statement on breeder safety. All known potential safety problem areas have long been identified and openly discussed in LMFBR documents in the public domain. These include the LMFBR environmental impact statement and the preliminary safety reviews for the Fast Flux Test Facility.

On the matter of breeding, Dr. Ford states that there is much discussion within the AEC of the fact that the breeder reactor may produce very much less new fuel that it was previously claimed to be able to provide. The facts known to the AEC on this matter are listed briefly:

"1. Estimates made in the mid-1960's of the breeding gain achievable with a mixed oxide fuel system in an LMFBR have, indeed, been revised downward. Over the intervening years more accurate nuclear data measurements have shown that the earlier data made the estimates too high. Thus, the expected replacement by breeding of 140% of the plutomium consumed now appears more like 125% in a properly designed mixed oxide core.

"2. Breeding in the first LMFBR Demonstration Plant will probably be about 115% with its mixed oxide core. This is due to deliberately conservative design to assure a healthy operating reliability margin. The AEC is not attempting as an objective to establish the breeding ratio but rather we wish to establish the ability of breeder reactor to work in a normal plant operating environment. There is no doubt that core designs more advanced than this first demonstration core can reach the 125% figure.

"3. Mixed carbide fuel systems, which are under development, are estimated to achieve 140% breeding. There is no obvious technical basis for supposing this estimate is not correct."

JCAE REFUSAL TO HOLD OPEN SAFETY HEARINGS

Dr. Ford attempts to indicate that the Joint Committee on Atomic Energy is restricting testimony at its reactor safety hearings to the AEC and staff. In actuality, the Joint Committee's announced plans indicate a full-scale study of the entire range of nuclear power reactor safety, of which the first two phases were completed this year. The JCAE's public announcements state that AEC will testify on its emergency core cooling systems criteria on January 22, 1974. Testimony from representatives of the nuclear community, environmental groups and the public at large on nuclear safety issues is scheduled for January 23 and 24, 1974.

The Commission feels that these hearings are affording a unique forum for full public discussion of the facts on nuclear safety. Enclosed is the prepared statement of the AEC Director of Regulation, which presents insights on Regulatory safety philosophy and how the Regulatory organization performs its work in the interests of the public. Testimony of each of the Commissioners and other principal staff involved in nuclear safety will be provided if desired.

The AEC has worked with the JCAE for many years, profiting substantially from its oversight. The hearings on nuclear safety are but one example of the probing into issues which has characterized this Congressional oversight. I urge you and your Committee to discuss Dr. Ford's views with the JCAE. In our response, we have attempted to answer succinctly the general issues raised by Dr. Ford. You, of course, may have other questions which you wish addressed. If you wish any further information, please do not hesitate to request it.

Sincerely,

DIXY LEE RAY,
Chairman.

Enclosures: As stated.

Enclosure 1

ABNORMAL OCCURRENCES AT NUCLEAR POWER PLANTS

The statement attributed to Commissioner Doub regarding the number of abnormal occurrences at nuclear power plants is substantially correct, but fails to point out that the statement was preceded by the following: "An AEC review of the operating history associated with 30 operating nuclear reactors has shown during January 1972 to June 1973 no nuclear accidents occurred and no member of the public was injured in any way due to radiological causes."

The data on abnormal occurrences were cited as one measure to indicate the need for an effective quality assurance program during operations. An effective program will result in better surveillance of nuclear power plants in operation, thus resulting in disclosure of conditions which result in abnormal occurrence reports. It will also result in a reduction in the number of occurrences which require reporting.

The reporting requirements which are imposed by AEC on its licensees are quite demanding. The purpose of the reporting of events, such as those referred to above, during component fabrication, plant construction, preoperational testing and routine operations is to further the rapid adjustment and corrective actions taken for the plant involved. Of equal importance, announcing them will assure that such experience will be shared with the nuclear industry. Indeed, the short history of light water reactors already has many examples of improvements made in succeeding generations of plants, or backfitted into plants already built and operating, to meet changes in standards to upgrade components and systems on the basis of feedback from prior operational experiences. Such advances are a positive objective of Government and industry in the nuclear field, and can be expected to continue as additional information is obtained from day-to-day operational experiences and from research and development.

Enclosure 2

AVAILABILITY OF NUCLEAR PLANTS

It is true that nuclear plants have experienced delays in construction and licensing and equipment malfunctions once in operation. However, a careful look at the operating statistics indicates that the availability of nuclear plants and fossil plants for producing power are comparable and the equipment malfunctions experienced are quite similar. Information on the availability of nuclear plants is presented in a soon to be released report (OOE–ES–1) entitled "Evaluation of Nuclear Power Plant Availability." According to this report a study of the operating records for 1972 of 19 licensed nuclear power plants indicates the average plant availability to be 73% where plant availability is defined as the actual hours of generator operation divided by the total clock time during the period. For fossil plants of all types (oil, coal, gas turbines), EEI has reported for a 12 year period (1960–1971) the average plant availability to be as follows: 600 Mwe and greater—73%; 390 to 599 Mwe or greater, the average plant availability for nuclear and fossil plants is about equal. For plants less than 600 Mwe, the fossil plants have the edge.

Analysis of the limited available data for nuclear plants as a function of their length of service shows that the average plant availability increases from about 69% during the first year of operation to 80% or above after the plants have operated for 3 to 4 years.

NUCLEAR PLANT AVAILABILITY

	Number of facilities included	Availability (percent) average plant
Years of service:		
0 to 1	16	69
1 to 2	11	76
2 to 3	8	73
3 to 4	3	80
4 to 5	2	90
5 to 6	2	83

Enclosure 3

OCCURRENCES AT SPECIFIC PLANTS

1. *San Onofre.*—A statement is made that "a very serious accident" occurred at San Onofre on October 21. The accident was serious in that it will require considerable time and money to repair. It did not represent any hazard to the public or to the station operating staff. The accident, which occurred in a non-nuclear system, was the failure of a blade in the turbine, and consequent damage to other blades in the turbine. This type of failure, while uncommon, has occurred many times in fossil plants.

The shutdown was prompt and orderly. During the shutdown all plant systems functioned as required, but one subsystem experienced minor damage which is being corrected. The damage did not prevent proper functioning of the system.

2. *Millstone.*—The extended plant shutdown at Millstone was caused by leakage in the turbine condenser. As a consequence, sea water intruded into the steam system. Such an occurrence is not uncommon in fossil power plants. In the case of Millstone, since it is a nuclear plant, the AEC required an extensive cleaning and inspection effort before allowing the plant to be returned to service. Some damage was found and corrected. The corrective action included replacement of the control rods which were suspected of being damaged by the salt water intrusion.

Shortly after restart of the reactor, the manufacturer, in review of manufacturing records, found that some of the replacement control rods might have been assembled in a manner which could change their control effectiveness. The reactor was promptly shut down, and the control rods were examined in detail. Some were replaced.

3. *Pilgrim and Vermont Yankee.*—Reference was made to restriction of Boston Edison's Pilgrim plant to operation at 50% power. This power restriction is based on experience at a similar plant in Switzerland, where during refueling of the reactor some damage to core components was found. Analysis of the situation disclosed that the damage was caused by vibrations caused by operating the reactor at high power levels. Detailed nuclear, thermal, and hydraulics evaluation were made by the manufacturer, General Electric. General Electric concluded that, while the situation was obviously undesirable, the safety of operation of the plant had not been jeopardized. General Electric informed the AEC promptly, and advised us that there were only two General Electric reactors of similar design in service in the United States where the same problem might be developing, Vermont Yankee and Pilgrim. Vermont Yankee was then in a shutdown condition. General Electric advised Boston Edison to temporarily limit power level to 50%. After critical review of the analytical information, the Regulatory staff concluded that the restriction on power level was a prudent precaution, but that there was no need to shut the reactor down immediately. Design modifications to correct the situation have been made at Vermont Yankee, and will be made at Pilgrim in the near future.

USING THE ENERGY CRISIS TO PASS EMERGENCY LEGISLATION

Mr. Ford. Could I just add one word, Senator? The emergency nature of the legislation is something that is quite difficult for me to grasp, because there has recently been a study by the Federal Power Commission of the delays associated with nuclear powerplant licensing, and the delay introduced by public hearings, lawsuits, and the like ranks as factor No. 7 on the list of eight factors listed according to their importance. And the principal difficulty in delaying nuclear powerplants is the complexity of constructing these plants that has meant very poor labor productivity.

We can provide you with a copy of this study. But it makes it quite plain to us that what is really taking place in these proposals to speed up nuclear powerplant licensing is an attempt to use the present energy crisis and political atmosphere to push through a number of proposals which would not get very far if they were weighed in calmer times on their merits.

I think one thing which is sliding along quite quietly here is the breeder reactor, which I have only mentioned briefly. The basic

feeling among persons who have looked into this matter, including a number of the AEC's own people, is that the breeder safety problems are much more pronounced than those of light water reactors. That is, present reactors have problems that they think are remedial. The breeder reactor, by contrast, appears to have inherent safety problems. The greatest secrecy has been shown by the AEC, in addition, on the economics of the breeder reactor. There is much discussion inside the AEC of the fact that the breeder reactor may be able to breed—that is, produce—very much less new fuel than it was previously claimed to be able to provide.

So that, all in all, one suspects that this legislation and the research proposal of Chairman Ray that gives pride of place to the breeder, is an attempt to use present circumstances to get this through. Because obviously, the breeder reactor, even according to most optimistic schedules, is not going to be able to do anything for the world, anything for this country, in terms of providing energy until the 1980's. And one wonders why the authorizing legislation for a great push in this area has to be done in an emergency atmosphere this winter.

I think what should be quite apparent is that what Congress is being presented by the administration is the work-product of the AEC, and it is being asked for a rapid endorsement of this work-product. But the critical problems on reactor safety have not been laid before the Congress. The Joint Committee on Atomic Energy has studiously refused to hold hearings in which these safety problems could be aired, in which the AEC's own experts could be questioned.

So that it is my observation—maybe there are other factors on your mind—but it is my observation that there is really no apparent justification for emergency treatment of nuclear power.

Senator RIBICOFF. Thank you very much. And I hope that we have an opportunity of calling on you at some future date for some suggestions and advice.

Mr. FORD. Thank you. It was a privilege to appear here.

Senator RIBICOFF. Thank you very much. You have been very helpful, and I think you have put this problem in perspective that was sorely needed.

All right, Marc Messing, Ann Roosevelt, and Charles Bering.

TESTIMONY OF MARC MESSING, ENVIRONMENTAL POLICY CENTER; JEFFREY KNIGHT, FRIENDS OF THE EARTH; AND CHARLES BERING, ENVIRONMENTAL ACTION

Mr. KNIGHT. My name is Jeffrey Knight, and I am appearing for Ann Roosevelt.

Thank you, Mr. Chairman, for allowing us to appear here for our views on the proposed legislation for Federal energy research and development functions.

Today we have the unprecedented opportunity to undertake rational planning for our future energy needs. This effort must not be shortsighted. We must not put all our eggs in one basket, nor favor any one research area—whether it be nuclear energy or coal—over others. We should keep in mind the goal of our endeavors—the development of cheap, abundant, and environmentally clean energy. Therefore, in any

Manhattan project type program, we should stress those energy options for R. & D. which would provide this plentiful, clean energy.

We must not be content with the old solutions—with improving supply in fossil fuels and nuclear—we must strike out now and take decisive action to find new energy sources and supplies. In any new government energy R. & D. organization it must be made clear that a crash program is intended in the areas of solar, fusion, and geothermal energies, and in other areas which show the promise of providing clean and plentiful energy.

We believe that reorganization of the research and development functions of the Federal Government is urgently needed. However, S. 2744 does not provide a suitable formula for that purpose. This bill lacks the goals that any energy reorganization effort must pursue, and leaves Congress with little voice in the policy formation of that new agency. We urge you to institute changes which will lend a more rational and more flexibile structure to this proposal. An organizational chart of ERDA incorporating our suggestions is attached.[1]

The present structure will divide ERDA into five divisions for: One, fossil fuel research; two, nuclear research; three, energy safety and conservation; four, advanced systems research; and five, military applications and national security. We have major objections to this structure and its implications for the Nation's energy policy. The structure of the new agency will heavily influence which areas of energy research will be accelerated and which areas will be retarded.

ENERGY CONSERVATION

The proposed structure is weighted towards development of the intermediate energy forms, nuclear and fossil fuel systems, to the detriment of more advanced and permanent systems such as solar, geothermal and fusion, and what we feel is the most important avenue of all, energy conservation.

The one essential ingredient in any new program must be an ongoing broad-scale commitment to energy conservation. In the "Weekly Energy Report" for November 19, an AEC representative is quoted as saying that conservation "has no sex appeal." It is this kind of attitude that we must avoid. Conservation is recognized by the administration as being the key to getting us over the energy shortage this winter, but true conservation in the near and midterm will demand a wide research effort. Energy conservation does not just mean using less, it means inventing new energy-efficient goods and developing processes for the more efficient and economic use of what we have. It means planning and design so that consumers will be able to use less energy and will not be compelled to use more.

It is highly unsatisfactory to lump environmental and safety con-concerns with energy conservation in one division of ERDA. The emphases are different and both fields will suffer as a result. Therefore, we suggest you split the Administration for Environment, Safety and Conservation into two new Administrations, each under an Assistant Administrator, one for Energy Conservation and one for Environment and Safety.

It is also unsatisfactory for the military applications section to be placed in a high technology civilian research and development agency.

[1] See appendix, p. 625.

This section will do research in nuclear weapons, and we recommend that it be transferred intact into the Department of Defense.

A major fear of environmentalists is that promising, renewable energy sources will get short shrift in any new energy research structure. ERDA, as proposed, will most likely determine what the mix of energy sources will be in the future merely by establishing funding priorities. The danger, of course, lies in favoring a single solution over the others.

No where in this bill is there a policy commitment by Congress to stress development of clean, renewable energy sources such as solar and geothermal energy. In fact, the structure as proposed in this bill, because it lumps all renewable energy sources into one division, would downplay the importance of those technologies in relation to nuclear energy and fossil fuels. It is imperative that renewable energy sources to be developed as rapidly as possible.

Therefore, we urge that Congress include policy formulations in any legislation and establish that renewable energy development is a priority area. A possible mechanism to achieve this would be to split out solar energy and geothermal and have an Assistant Administrator responsible for each, plus an Assistant Administrator for all other advanced systems. Through this mechanism, renewable sources would be given a better chance to compete for funds with nuclear energy and fossil fuels.

RECOMMENDED CHANGES

Other changes we recommend include:

One, insertion of a new section describing annual reports which ERDA should make to Congress. Such reports should include, but not be limited to, an account of the state of energy R. & D., promising new technologies not being adequately developed in the private sector, progress in developing new energy producing and conserving technologies and implementing commercial application of those technologies, impediments to the transfer of research and development to the commercial sector, and suggestions designed to overcome such impediments.

Two, a provision amending section 108(3) of the bill so that in the disposition of patent rights, specific protection for small entrepreneurs is provided and so that the big companies that now dominate the energy industry are not the recipients of exclusive patent rights.

Three, the establishment of an Office of Inventions which would seek out and provide financial support for ideas from independent scientists, inventors and small businesses. We must not allow the vitality and innovation that have come from these areas to be excluded from the national effort.

Four, some sort of conflict of interest provision which would prohibit people with backgrounds in industry from assuming major policy formulating positions in the new agency.

Five, a provision establishing qualifications for the Administrator and Deputy Administrator which would preclude anyone from assuming these positions whose previous experience has centered around only one energy technology.

Another danger in the proposed legislation is that nuclear energy will be overemphasized at the expense of other solutions. The proposed Energy Research and Development Administration will be over-

whelmingly staffed by Atomic Energy Commission personnel, despite the addition of some employees from Interior and other agencies. There are no safeguards in the legislation to assure that overfunding of nuclear energy at the expense of fossil fuels, solar and geothermal will not continue. The New York Times, in an editorial on Dec. 3, 1973, points out the problem:

> The arguments are becoming ever more persuasive that the nation should lean more toward coal, solar and geothermal processes and nuclear fusion to meet its energy needs a decade or more hence and plan today's research and investment accordingly. Little is gained by replacing a politically unreliable fuel—oil—with a technically unreliable and potentially dangerous power from nuclear fission.

The proposed ERDA structures will probably continue the funding of nuclear fission at the expense of other alternatives. Recent indications are that Dr. Dixy Lee Ray has proposed the Nation's first 5-year plan for energy development, concentrating heavily on nuclear energy. Estimates are that funding for nuclear fission will exceed 40 percent of the $10 million proposed budget. In contrast, only 2 percent of the proposed budget would go to solar, and less than that, about 1.8 percent, to geothermal.

CONGRESSIONAL SUPERVISION

Dr. Ray's proposal highlights the necessity of Congress establishing the priorities and safeguards in any proposed energy research legislation. For example, since World War II, this Nation has spent about $30 billion in nuclear research and development, and only about $20 million on solar energy. As long as such misallocation of resources continues, solar energy and other advanced and unfunded technologies will remain future hopes, and not present realities. We must understand that present R. & D. processes and proposed fundings are, to an extent, self-fulfilling, and unless we decide that these advanced systems are valuable and necessary, they will always remain a promise unfulfilled.

S. 2744, as presently structured, does not create the means to fulfill that promise. We think that incorporating our suggestions will help achieve that end, and help facilitate the wide range of effort that is needed.

Thank you, Mr. Chairman, for allowing us to comment on this bill, and we hope that you will consider our suggestions.

Senator Ribicoff. Mr. Messing, since time is limited, we have read your statement, could we insert it in the record, as if read, and we can go to the questioning and develop what is on our mind, and get your point of view.

Without objection, the statement will go into the record as if read.

[The prepared statement follows:]

Statement of Marc Messing, Energy Policy Staff, Environmental Policy Center

My name is Marc Messing and I am representing the Environmental Policy Center. The Environmental Policy Center has previously submitted as joint testimony, the text of a letter dated December 4, 1973, and addressed to the members of the House Committee on Government Operations. A copy of that letter is attached to my written testimony. I believe that the substance of that letter has already been summarized this morning, and at this time I would like to make a brief statement regarding concerns of the Environmental Policy Center not expressed in the text of that letter.

Since the President's address to the Nation on November 7th, the Congress has acted with unusual urgency in actions upon a wide range of energy-related measures, ranging from authorization for the Trans-Alaska Pipeline to the implementation of year-round Daylight Savings time, and including deepwater ports, energy conservation, reductions on automotive speed limits, the Petroleum Allocation Act, the National Energy Emergency Act, the National Energy Research and Development Policy Act, the Federal Energy Administration Act, and the legislation which is being considered here, the Energy Reorganization Act of 1973.

As we are all aware, the Petroleum Allocation Act authorizes the President to allocate all crude oil, residual fuel oil, and refined petroleum products into or coming into the United States; and yet despite the passage of that bill within the past several weeks, even before there has been an opportunity to implement the authorities of the Act, the Senate has passed the National Energy Emergency Act of 1973 which supersedes the Petroleum Allocation Act and not only authorizes, but directs the President to implement allocation, rationing, and energy conservation programs which pertain to the conduct public affairs and our private lives to a degree which is unprecedented within this country in my lifetime. In fact, Section 313 of the National Energy Emergency Act extends even beyond the allocation and rationing of fuels to allocation of materials and equipment "associated with exploration, production, refining, and the required transportation of energy supplies" throughout the ation.

Members of the Congress, spokesmen for various federal agencies, and members of the public, have been alert to the emergency of these problems for most of the last ten years, and there is no doubt that appropriate action on the part of either the Administration or the Congress could have averted, or ameliorated the crisis in which we find ourselves today. Nonetheless we are now in the process of vesting an Administration whose own negligence has exacerbated these problems, with extraordinary powers in the hope that they will finally act upon and resolve them. And the result, at least at the moment, is merely a additional increment in the powers of the Executive.

We are fortunate insofar as this winter has not, thus far, been harsh. Nonetheless we are beginning to feel the impacts of energy shortages in numerous ways. We are experiencing material shortages, such as chlorine, as a result electric utility contracts on "interruptible" basis, which have already been interrupted; we are becoming aware of potential shortages in materials such as PCV's which are utilized in everything from phonograph records to the plastic syringes in hospitals; we are becoming sensitive to the fact that such diverse products as lipsticks and drugs are derived from our petroleum resources (including natural gas); and there have been some concerns that there may be shortages of petroleum feedstocks for agricultural fertilizers at a time when our grain stocks are at their lowest level in twenty years. Therefore, our energy crisis is not only one of fuels for transportation and heating, and is not one which will effect us only this winter, but is one which is integrally related with all facets of our lives, and which will continue in one form or another for the foreseeable future.

However, none of these problems demands, nor justifies, concurrent action on all the energy legislation presently moving through Congress. The Petroleum Allocation Act, the Energy Emergency Act, the creation of the Federal Energy Administration, the Energy Conservation Act, and perhaps, it might be argued the Research and Development Policy Act, are all measures which depend for their value upon the timeliness of their enactment. The Energy Reorganization Act, on the other hand, does not depend for its value upon its immediate passage. Quite to the contrary, in fact, it demands a deliberation and consideration which we cannot afford to give the other pieces of emergency legislation, and there are at least two compelling reasons for this. Firstly, it should be stressed, that our energy crisis is not a short term problem or one from which we will emerge unaffected. The United States owes its strength and its progress in large part on its resource and energy wealth, and it is entirely depedent upon these foundations for its continued strength. But the United States is no longer an energy rich nation, and entirely apart from the vicissitudes of foreign affairs, it will be forced to determine the limitations of its own energy budget, and to address its needs accordingly. It is clear that this will entail maximizing our energy resources through fundamental energy conservation programs, and it is clear that this will entail developing solar energy as an integral element in our operating energy budget. Solar energy is, of course, the ultimate source of satisfying our energy needs. Beyond this, however, it is difficult to predict the patterns through which our energy needs will be met. It is impossible to accurately determine the levels

of energy which we will be consuming, the patterns of our consumption, the actualities of our supply/resource bases; or the innumerable ways in which we might be able to adjust to different energy mixes in the overall energy picture. Therefore it would seem prudent to wait, at least until we have a better understanding of our immediate energy crisis, and until we have had a chance to assess this energy crisis in the light of the emergency actions which we have just begun, before restructuring our entire federal energy apparatus for dealing with the continuation of these problems on a long term basis.

Secondly, it might be argued that reorganization of the federal energy machinery at this time, might encumber the more pressing problems of administering the emergency programs. It is unclear to us, from our readings of the Research and Development Policy Act and of the Energy Reorganization Act, precisely how the two Acts, if enacted, will dovetail with each other. Each appears to establish a mechanism, in the one instance an administrator and in the other instance an interdepartmental management board, for determining federal R&D priorities. It appears entirely inconsistent to us to establish mechanism on the one hand to disperse $800,000,000 per year for research and development, while establishing elsewhere, though at the same time, another mechanism for determining national R&D priorities. This conflict appears inherent in the two pieces of legislation as we now have them, and this is not the sort of difference which should be worked out in conference; rather, it is the sort of difference which should be resolved after extensive additional hearings.

Finally, I should mention that reorganization is not the key, and may not even be necessary, to the solution of our energy problems. In 1973 alone the President has reorganized the executive-level energy operations three times: first establishing a super-council consisting of Messrs. Erlichman, Kissenger and Shultz, then creating the Energy Policy Office of Governor Love, and most recently establishing the Federal Energy Office of Mr. Simon. We support this last action as consistent with the energy emergency and desirable for addressing our most urgent problems during the coming year.

However, although we support the need for a more extensive reorganization of the federal energy bureaucracy such as that proposed by this legislation, we strongly oppose it at this time. We agree that the Atomic Energy Commission should be divided and that the licensing and regulation of nuclear facilities should be separated in an independent Nuclear Energy Commission. We would further agree that the Atomic Energy Commission might have the best track record and be the most technically capable agency in the field of energy research and development, and thus should be the core around which a reorganization should be structured. But if we accomplish this reorganization hastily, and structure a new comprehensive energy research and development agency improperly and without the flexibility to address the problems which may emerge over the coming years, then we will recapitulate the problems embodied in the Atomic Energy Commission today, and we will retard, rather than accelerate the development of a sound, comprehensive, and environmentally responsible energy management.

We therefore urge that action on this important legislation be deferred at least one year, or until the expiration of the national energy emergency.

DECEMBER 4, 1973.

MEMBER,
Committee on Government Operations,
U.S. House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN: On Wednesday, December 5, 1973, the House Government Operations Committee will consider, in markup, the "Energy Reorganization Act of 1973."

We believe that reorganization of the research and development functions of the Federal government is urgently needed. However, this particular legislation does not provide a suitable formula for that purpose. We urge the Congress to set the goals that any energy reorganization effort must pursue. This bill lacks such goals, and leaves Congress very little voice in the policy formulation of that new agency. We hope that you will consider proposing changes which will lend a more rational and more flexible structure to this legislation. An organizational chart of the structure as it is presently in the bill is enclosed (Chart I) as well as a chart incorporating our changes (Chart II).

In its present form, the new Energy Research and Development Administration (ERDA) will be run by an Administrator and will be divided into five sections, each headed by an Assistant Administrator for: (1) Fossil Fuel Research, (2)

Nuclear Research, (3) Environment, Safety, and Conservation, (4) Advanced Systems Research, and (5) Military Applications. We have major objections to this structure and its implications for the nation's energy policy. The structure of the new agency will heavily influence which areas of energy research will be accelerated and which areas will be retarded.

The proposed structure is weighted towards development of the intermediate energy forms, nuclear and fossil fuel systems, to the detriment of more advanced and permanent systems such as solar, geothermal, and fusion, and the most important avenue of all, energy conservation.

It is highly unsatisfactory to lump environmental and safety concerns with energy conservation. The emphases are different, and both fields will suffer as a result. Therefore we suggest you offer an amendment which will split the Administration for Environment, Safety, and Energy Conservation into two new administrations, each under an Assistant Administrator, one for Energy Conservation and one for Environment and Safety.

It is also unsatisfactory for the Military Applications section to be placed in a high technology civilian research and development agency. This section will do research in nuclear weapons. It should be transferred intact into the Defense Department.

Further, nowhere in this bill is a policy commitment by Congress to stress development of clean, renewable energy sources, such as solar and geothermal energy. In fact, the structure as proposed in this bill, because it lumps all renewable energy sources into one division, would downplay the importance of these technologies in relation to nuclear energy and fossil fuels. It is imperative that renewable energy sources be developed as rapidly as possible. Therefore, we urge that Congress include policy formulations in any legislation and establish that renewable energy development is a priority area. A possible mechanism to achieve this would be to split out solar energy and geothermal and have an Assistant Administrator for each of these plus an Assistant Administrator for all other Advanced Systems such as wind, tides, and MHD. Through this mechanism, renewable sources would be given a better chance to compete for funds with nuclear energy and fossil fuels.

Other changes should include:

1. insertion of a new section describing annual reports which ERDA should make to Congress. Such reports should include, but not be limited to, an account of the state of energy R & D, promising new technologies not being adequately developed in the private sector, progress in developing new energy producing and conserving technologies and implementing commercial application of these technologies, impediments to the transfer of research and development to the commercial sector, and suggestions designed to overcome such impediments.

2. a provision amending section 108 (e) of the bill so that in the disposition of patent rights, specific protection for small entrepreneurs is provided and so that the big companies that now dominate the energy industry are not the recipients of exclusive patent rights.

3. the establishment of an Office of Inventions which would seek out and provide financial support for ideas from independent scientists and small business.

4. some sort of conflict of interest provisions which would prohibit people with backgrounds in industry from assuming major policy formulating positions in the new agency.

5. a provision establishing qualifications for the Administrator and Deputy Administrator which would preclude anyone from assuming these positions whose previous experience has centered around only one energy technology.

Another danger in the proposed legislation is that nuclear energy will be overemphasized at the expense of other solutions. The proposed Energy Research and Development Administration will be overwhelmingly staffed by Atomic Energy Commission personnel, despite the addition of some employees from the Interior Dept. and other agencies. There are no safeguards in the legislation to assure that overfunding of nuclear energy at the expense of fossil fuels, solar, and geothermal will not continue. *The New York Times*, in an editorial on December 3, 1973, points out the problem:

"The arguments are becoming ever more persuasive that the nation should lean more toward coal, solar and geothermal processes and nuclear fusion to meet its energy needs a decade or more hence and plan today's research and investment accordingly. Little is gained by replacing a politically unreliable fuel—oil—with technically unreliable and potentially dangerous power from nuclear fission."

The proposed ERDA structure would probably continue the overfunding of nuclear fission at the expense of other alternatives. Recent indications are that Dr.

Dixy Lee Ray has proposed that the nation's first Five Year Plan for energy development concentrate heavily on nuclear energy. First estimates are that funding for nuclear energy (excluding fusion) will be over 40%. In contrast, only 2% of the estimated total budget will go to solar and 2% to geothermal. Dr. Ray's proposal highlights the necessity of Congress establishing priorities and safeguards in any proposed energy research legislation. Since World War II, this nation has spent over $30 billion in nuclear research and development and only $20 million on solar energy. While such misallocation of resources continues, solar energy will remain a "future hope" and not a "present reality." We must understand that R & D prophecies are, to an extent, self-fufilling. Unless we decide that these advanced systems are valuable, they will always remain a promise unfulfilled.

H.R. 11510 as presently proposed does not create the means to fulfill that promise. Unless substantive changes, such as those outlined above, can be adopted, we urge you to oppose this legislation.

Sincerely,

ANN ROOSEVELT, *Friends of the Earth.*
JOSEPH LIPPMAN, *Citizen Action, Inc.*
PETER HARNIK, *Environmental Action.*
MARC MESSING, *Environmental Policy Center.*

Senator RIBICOFF. I personally do not believe that development of alternate energy resources and the environmental safeguards are mutually exclusive provinces. I think we can have both.

ENVIRONMENTALIST-ENERGY ADVOCATES CONFLICT

One of the great problems is the conflict between the energy advocates and environmentalists—and yet, my feeling is that if we work together with a take-off as well as a crash landing, we could eliminate many of these conflicts between the environmentalists and the energy advocates. How would you provide for better working relationships between the environmentalists and those who want more energy?

Mr. MESSING. Well, let me address this. I am Marc Messing of the Environmental Policy Center. I think the first step toward that would be the establishment of a national energy budget.

Historically, we have always been an energy rich Nation, and a materially rich Nation. With the dynamics of exponential growth that we are all now more familiar with, this is no longer the case. We are no longer an energy rich Nation. What we have to do is make a careful determination of how much energy is available to the Nation in a given year, and then provide for some basis of allocation or distribution, based on those estimates.

Senator RIBICOFF. Well, is it just a question of the budget, or does it take into account the planning? When oil was $2 a barrel, environmental safeguards raised the price of oil. Now that oil is $8, $9 a barrel, and going up, you could build in environmental safeguards and still be competitive.

Now, since there sometimes are conflicts, how do you coordinate the saving of the environment, conservation safety standards, with the development of alternate sources of energy? How do you see both objectives working together?

Mr. MESSING. Excuse me; let me backtrack just a moment. By establishing an energy budget, I meant to use an analogy rather than refer to an economic budget. I am referring to a planning process, essentially analogous to determining the national monetary budget; because we have to turn to an evaluation of our resources in terms of available energy, determine how much energy we can borrow, and

make judgments on that basis. Our environmental protection, for the most part, is based on minimum criteria. In establishing standards of the Clean Air Act, for example, we have tried to establish what is the absolute bare minimum; what is the necessary level that we must sustain, in terms of environmental quality, in order to sustain a reasonable quality of life, a protection of public health, and an improvement of the quality of life.

GOALS OF THIS NEW AGENCY

Senator RIBICOFF. What specific goals do you think, heading towards that, we should write into this legislation? What should be the goals of this new agency, keeping in mind that we do have the need for more energy, and we do want to protect the environment. Should we just say that?

Mr. MESSING. Let me say that we have to budget our energy resources much more carefully. We cannot make projections, as we have historically, on the amount of energy which we would like to have, or which we think we will demand by virtue of creating demand; and then we find ourselves, when we do this, in a position where we have to fulfill that. It is at that point where we run into a conflict between environmental safeguards and energy production.

The country, historically, has been extraordinarily wasteful, in terms of its energy resources. A first step must be an energy conservation program. To waste a half to two-thirds of our energy resources, the way we do, is unacceptable. Simply to pare the waste here would avoid most of the potential conflicts between the energy and the environment.

SAFEGUARDS IN ERDA

Senator RIBICOFF. What specific procedural safeguards would you want to see built into ERDA, to assure that all technologies are properly evaluated for their impact on the environment and public safety?

Mr. KNIGHT. Senator, I think that we could view it from another standpoint. The Senate, on Friday, passed an Energy Policy Act, I guess you could say, S. 1283, by unanimous vote; I think it was 82 to nothing. And that bill has a clause that says that the management section that is set up in there is only temporary, or until some other thing comes along.

Senator RIBICOFF. Well, I would asume that, if that goes through the House, what you are setting up in ERDA would be the management function to handle that.

Mr. KNIGHT, Right. I think that the wide-ranging proposals that that legislation contains in nonnuclear areas would not be adequately handled by the structure of ERDA as it presently exists. It is incredibly diverse. With all the various corporations and technologies that it recommends exploration of, I am not really sure that ERDA, as it now stands, would adequately be able to meet the demands of S. 1283.

Senator RIBICOFF. Let me ask you, should the Assistant Administrator for Environment and Safety be required to submit impact statements on all energy projects developed by ERDA's other division?

Mr. MESSING. I think so, absolutely. There has been at least one court challenge on a related issue, regarding the development of the liquid metal fast breeder reactor, and I think that the expressed

interest in that case was that impact statements should be filed at the prototype research and development stage, or, in other words, on any research and development projects which would themselves impact upon, or may potentially have major impact upon the environment.

Senator RIBICOFF. Well, how should such recommendations be assured that they will be given due consideration by the Administrator?

Mr. MESSING. I think provisions for section 102 statements, such as you suggested, would be an appropriate mechanism, and this responsibility could be assigned to the Administrator for conservation under this title.

Senator RIBICOFF. Now, you gentlemen recommend a separate Assistant Administrator for energy conservation. How should such a division be structured so that energy demand considerations have a maximum impact on an agency whose main mission would be to develop new forms of energy supply? What do you view as the most promising technologies conserving energy over the next year or two?

Mr. KNIGHT. For conserving energy over the next year? Well, Senator, this bill will not affect the next couple of years.

Senator RIBICOFF. I know, but the FEA, the whole general problem, what do you feel is the best method of conservation for the immediate future, today, or tomorrow?

Mr. MESSING. I think that the administration's lack of attention to this problem over the past few years, when other Federal agencies, public interest groups, and Members of Congress were bringing it to attention, is primarily responsible for the situation we find ourselves in now. The principal mechanisms we are dealing with, the necessary first steps, are contained in the Petroleum Allocation Act, Emergency Energy Act as the Senate has passed it, and the Federal Energy Administration; I think there are adequate provisions there for dealing with it. To get to other part of that question——

Senator RIBICOFF. I know that; but where do you people think that you could save and conserve energy today? What method should be used for today, and for the long run? Let's take both.

Senator PERCY. Mr. Chairman, could I just interject a comment?

Regretfully, I am not able to delay my 12 o'clock appointment, because he has another one right after that, so I will have to go upstairs.

I would first like to thank the three of you for being here, and pay tribute to the organizations that you represent, and express deep appreciation on behalf of myself and my staff for all of the help through the recent years that you have provided to us. It has been invaluable.

I have a number of questions that I would like, Mr. Chairman, to submit for the record, then, for your consideration, and it would be important that we do have your responses back before we finish marking up this legislation. So if I could just leave those with the staff, and I regret once again that I have a conflicting appointment, but thank you very much for being here.

[The material referred to follows:]

Question 1: Last Tuesday, in his opening remarks at the beginning of these hearings on the ERDA bill, S. 2744, Senator Jackson said the following:

"The bill which we are considering today to create an independent energy R&D administration, ERDA, cannot serve either of the functions which are needed. It does not contain the research strategy, objectives, budget goals and grants of new authority which are so urgently required to get a comprehensive

non-nuclear research program underway. It does not provide an adequate permanent organization which is appropriately related to other Federal responsibilities for energy.

"The principal objective of S. 2744 is to isolate the research function from other aspects of energy policy.

"Therefore, although I agree that provisions of the new measure should be considered, I am reluctant to consider them in isolation from the concerns of overall energy organization.

"The measure does not set forth Congressional guidance concerning the strategy, priorities, and objectives for non-nuclear energy research. The technologies which should be considered, the management approaches which are authorized, and the budgetary levels which might be anticipated are all left to the discretion of the Executive Branch."

Do you agree with Senator Jackson's comments?

Answer: Yes. Under this bill the pro-nuclear bias that has hindered all other energy research efforts will be strengthened and given a seminal role in formulating the nation's future energy resources. We are concerned that S. 2744, by placing the Atomic Energy Commission in the lead of the new ERDA, will insure that that bias remains dominant. By not providing for more than a general structure for ERDA, the bill leaves the organization of future, non-nuclear efforts to executive discretion. Further, that skeleton structure as it stands tends to constrict non-nuclear, non-coal research.

The idea of a centralized energy research and development structure is not alien to us, but the idea that the organization can be structured before its goals are established seems to be asking for trouble should the structural emphases conflict with energy policy. One must first legislate that policy, as the Senate has done by passing S. 1283, and then one must create an organization to administer it. Even a cursory glance at S. 2744 will indicate that it does not meet the demands created by S. 1283, and would not facilitate the realization of those goals.

Question 2: Have you had a chance to read the House ERDA bill, H.R. 11510, which has already been reported by the House Government Operations Committee? If so, are you satisfied with it, and do you think this Committee should accept the House bill and attach it as a separate title to the Federal Energy Administration bill we are marking up this week? That would be one way of assuring that both proposed new agencies, ERDA and FEA, are brought to a vote in both Houses of Congress before adjournment.

Answer: H.R. 11510 is almost identical to S. 2744, and as the answer to the last question and our testimony indicates, is unsatisfactory. To attach it as a rider to the Federal Energy Administration bill would be ill-advised. S. 2744 sets up a structure that will be with us for many years to come, a structure that demands careful and thoughtful consideration and investigation. Attaching it to the FEA bill would circumvent this deliberative process, which is one of Congress' strong points. The short delay caused by a thorough consideration of this proposal is nothing compared to the long term difficulties it could thus avoid. We urge you not to attach the bill to the FEA proposal.

Question 3: If you are familiar with the bill to create a Federal Energy Administration, I would like to ask you about the relationship between the emergency powers of that agency and the requirements for protecting the public safety and the environment. In trying to cope with the immediate energy shortages, should the FEA have the authority to temporarily suspend regulations of either the EPA on air quality or the AEC on nuclear power plant licensing?

Answer: No one can argue with the need to provide the fuel that will get us through the winter. And if this means burning high-sulfur coal for awhile, so be it. However, we cannot fall prey to the delusion that the concerns of our energy needs are incompatible. They are not. Most of the proposals to abridge environmental safeguards in the face of the energy crisis will not significantly alter that crisis and will neglect the very real problems these environmental regulations are addressed to. The advocates of such moves wish to avoid the costs of environmental safeguards, costs that have only been recently thrust upon them. As Russell Train, administrator of the Environmental Protection Agency, said earlier this month:

"Ripping up the Clean Air Act, and ripping off all environmental constraints that industry may find uncomfortable or some individuals may find inconvenient, will do nothing to solve our supply problems in the months ahead.

"Relaxing or relinquishing our environmental effort will release, over the long run, only marginal amounts of supply, and over the short run no new supply at all . . .

"There are some who tell us that all we have to do to warm things up is to tear up the Clean Air Act. There are some who tell us that the environmental effort is responsible for the energy crisis. There are some who tell us that a little pollution never hurt anybody.

"What the people say simply is not true, and they know it. What an environmental sellout will do is open even wider the whole Pandora's box of pollutants that the Clean Air Act and allied measures are helping us to close.

"The primary purpose of the Clear Air Act, the various standards we have set, and the steps we have taken to carry it out, is to protect public health by cleaning our air of these pollutants . . .

"The way to achieve reasonable solutions is to defer statutory deadlines where needed rather than flatly to prohibit specific types of controls. . . .

"We must begin by facing the fact that there is relatively little we can do to significantly increase energy supply at this time. What we can do is cut demand whereever possible. *We will never come to grips with either our energy or our environmental ills until we understand that they stem essentially from the same source from patterns of growth and development that waste our energy resources just as surely and shamefully as they lay waste our natural environmental.*"

We agree with Mr. Train, and add as an addendum to this testimony a copy of a Counter Energy Message recently proposed by environmental groups as an example of what can be done. As to your specific suggestions, we would be amenable to temporary, case-by-case suspension of clean air stationary standards if it meant that certain high sulphur fuels could be burned. However, in this context, since high sulphur fuels often are cheaper than low sulphur fuels, we feel that the price difference should go to sulphur and particulate removal equipment, and not go as excess profits.

As to nuclear power plant siting and licensing, we are categorically opposed to any temporary suspension of AEC standards. Nuclear power plants are dangerous machines that in and of themselves could create widespread dislocation if the highest and most diligent standards of regulation and monitoring are not followed rigorously. Any attempt to lessen public involvement in and government control of these facilities is senseless and dangerous. The plants take from six to eight years to build, and require minute inspection and control. Even so, they often have many unforeseen problems and are, at present, an unreliable energy source. Easing the licensing restrictions on these plants would have little positive benefit and could have many negative results.

Question 4: What do you think of the proposal put forward by Senator Cook in these hearings last week to suspend all driving one day a week as a means of conserving gasoline short of rationing?

Answer: This is an interesting proposal that merits consideration. However, the banning of all traffic on one day each week could have disastrous economic effects, since a large number of our population works on weekends. A more equitable solution would be to allow people to pick the day that they could not drive, and issue car stickers to that effect.

Question 5: What do you think of the suggestion I advanced last week when Roy Ash was at the witness table, to try the 4-day work week nationwide as one way to both conserve fuel and save jobs?

Answer: This proposal is questionable. Creation of a four-day work week would also create more three-day weekends, which could be an inducement to people to travel more and use more fuel in recreational activities than they would were they working that extra day. The proposal also is not clear as to whether we would have 8-hour or 10-hour days. The former would cut our productivity and/or increase the cost of living by inflating prices to handle the influx of new workers. The latter would be bitterly opposed by labor groups, and also might be counterproductive.

Question 6: What do you think is the best organizational arrangement for the important function of coordinating all energy policy in the executive branch and advising the President on energy policy? Should this function be in a single energy czar in the White House like Governor Love was, a 3-member advisory council like the CEQ, or the head of a powerful operating agency like the Federal Energy Administration?

Answer: Since the jobs of coordinating energy policy and advising the President are different, I suspect they would need different structures. For advising the

President, we would prefer something along the lines of CEQ. For coordinating energy policy, the need calls for a slightly larger organization, also headed by a commission and not a single person. This would facilitate top-level coordination of various areas of concern.

Press Release and Notice of Press Conference

For Release 10 A.M. Wednesday, November 21, 1973.
Conference: 10 A.M., 1714 Massachusetts Ave., N.W. Conference Room.
Contact Dr. James B. Sullivan at Center for Science in the Public Interest 332–6000.

ENVIRONMENTALISTS COUNTER ADMINISTRATION PROGRAMS

Representatives of environmental and citizens groups criticized the Nixon Administration's energy program today, calling it "anti-environmental and anti-consumer". While supporting several of the President's proposals, the groups said the overall program was capitulation to long-sought-after corpcrate goals. The organizations presented their own program of priorities in an "energy counter message."

The environmentalists argued that existing environmental controls have not contributed in any significant degree to present energy shortages. The groups presented evidence that one of the Administration's proposals—speeding up licensing of nuclear plants—may actually drain off more energy than it supplies and hence aggravate the present energy crisis.

Besides being environmentally detrimental, the groups criticized the President's strategies for seeking too much power for his own office and for Governors while downgrading public participation procedures such as public hearings.

Joining the environmentalists were several consumer and poverty oriented groups who asked that special consideration be given to people with low and moderate income. They asked that measures be taken to ensure that all people be allowed to share in the available supplies of heating fuel and that the poor not be discriminated against by "client shopping" dealers as is now being done, especially in rural areas.

Short and medium range strategies proposed in the group's energy counter message included:

Equalization of electric utility rates for small and large users.
Auto and appliance efficiency standards.
Shifting from truck freight to rail freight.
Utilization of wastes for heating fuel.
Limit on advertising of high energy consuming products.

Longer range strategies include:

Curtail use of non-recycled consumer and industrial products.
Provide mass transit operating subsidies from the highway trust fund.
Grant air pollution variances only as a last resort if energy conservation measures fail.
Expand deep mining rather than surface mining of coal.
Do not speed up licensing of nuclear power plants.
Expedite anti-trust action against the major oil companies.
Base energy strategies on a more realistic energy budget as well as seek environmentally sound energy sources such as solar power and nuclear fusion.

Coordinated by the Center for Science in the Public Interest, the "energy counter message" is supported by the following organizations and individuals:

Center for Science in the Public Interest.
Ellen Berman, Consumer Federation of America.
Marsha Curran, Common Cause.
Environmental Action.
Friends of the Earth.
Highway Action Coalition.
Movement for Economic Justice.
Metropolitan Washington Coalition for Clean Air.
National Clean Air Coalition.
National Consumers League.
National Intervenors.
Byron Kennard, Public Interest Economics Center.
James Ridgeway.

The America the Beautiful Fund.

Affiliation of individuals is for identification purposes.

ENVIRONMENTAL "COUNTER MESSAGE" ON ENERGY

There can be no doubt that the United States faces a serious energy shortage We share the President's concern that the U.S., with only 6 percent of the world's population, consumes over 30 percent of the world's energy. It is commendable that the Administration has expressed its desire to reduce the nation's spiraling usage of energy. We believe, however, that its basic approach is an attempt to delude the American public.

The major responsibility for reducing energy usage cannot be placed, as Administration proposals do, on individual consumers. Although environmentalists and consumerists support lowering thermostats, reducing auto speeds, and reducing unnecessary lighting and other superfluous uses of energy, we believe such an appeal to consumer sacrifice is being used as a pretext to avoid making hard decisions regarding corporate practices and structure.

We offer this energy "counter program" of principles and actions on which a sound energy policy should be based.

A major responsibility for alleviating the energy shortage must be placed on the corporate sector. By penetrating government at every key decision making level, industry has amassed enormous unbalanced political power in the energy area. It is in this political and economic problem, and not in environmental restrictions or even in consumer demand that the present crisis has its prime roots.

Strategies now being proposed or implemented by the Administration—the Trans-Alaskan pipeline, lax regulation of surface mining, offshore oil drilling, oil shale development, relaxation of air quality standards—rather than altering these patterns of unconstrained power, worsen them by capitulating to long-sought-after corporate goals. These goals are now being transformed, under a climate of energy hysteria, into specific government actions and policies.

To thus release industry from its responsibility will have severe consequences; it will: reverse progress made in safeguarding the environment, alter the nation's democratic political structure, and discriminate against those with low and moderate incomes.

It cannot be convincingly argued, as the Administration message implies, that existing environmental controls have contributed in any significant degree to present energy shortages. The Trans-Alaskan pipeline, for example, which has been delayed until now because of inadequate environmental planning, would not have been completed to supply oil at the present time even if there had been no delay. Nor can it be convincingly argued that environmentally destructive programs to alleviate the energy crisis—such as relaxing air quality standards and speeding up licensing of nuclear plants—will have more than a marginal effect in the near future. Speeding up nuclear plant licensing, in fact, may well drain off more energy than a speed up would supply.

The recent Senate action on relaxing clean air requirements, before it attempted any measures to conserve energy, was precipitous and irresponsible.

Besides being environmentally detrimental, the Administration's strategies threaten to alter our nation's basic political structure. Control over energy is equivalent to control over the entire economy of our country; the possessor of that control wields enormous power. Too much power should not be placed in a single individual, the President of the United States. Similarly, one-man control at the State and local levels runs counter to the democratic process. Eliminating public hearings on nuclear power plants and other projects would seriously limit democratic participation. Even in this time of energy crisis, decisions must be made by democratic consensus, not by executive decree.

In reaching consensus, those lower down on the economic ladder must receive special consideration. The majority (70 percent) of the population falls into the moderate to low income category. Measures should be taken to ensure that all people will be allowed to share in the available supplies of heating fuels and not be discriminated against by "client shopping" dealers as is now being done, especially in rural areas. If the work week is shortened, those employees who are not on a salary basis must be protected against losses in total income. More jobs should be created which are low in energy consumption (such as those in social programs). Such measures will provide jobs for persons displaced from high energy consumption jobs and will help serve a vital function in transforming our economy from a growth economy to a more steady-state economy. Middle and low income consumers should not be charged high prices and taxes to subsidize and insulate industry from the effects of the energy crisis.

SHORT AND MEDIUM RANGE STRATEGIES TO CONSERVE ENERGY

Many of the Administration's proposals for conserving energy are commendable but they omit many measures which would save considerable quantities of energy resources that are presently wasted:

Equalize utility rates for small and large users, in order to encourage more efficient energy use, revamp all utility rate structures in the interest of energy conservation (American industry uses 40 percent of the nation's energy, much of it wasted, but the large users pay only ⅓ to ½ the rate charged the small residential and commercial users. This backwards rate structure encourages waste).

Support the concept of a national power grid.

Utilize low cost loans or tax deductions to homes and commercial establishments for improving insulation.

Take measures to phase out the use of natural gas as a boiler fuel just as the Administration proposed electric generating plants switch from oil to coal, and at the minimum make those plants which use natural gas as boiler fuel pay the same rate as small users.

Make mandatory auto and appliance efficiency standards.

Outlaw gas lamps and develop more efficient gas range starters than present pilot lights.

Limit advertising of high energy consuming and luxury products.

Promote through excise taxes or other means small and lower fuel-use automobiles.

Shift from truck freight to rail and barge freight.

Utilize wastes for heating fuel.

Encourage more efficient industrial plants and practices.

LONG RANGE STRATEGIES

Base energy strategies on a more realistic energy budget and develop environmentally sound energy supplies such as solar power and nuclear fusion.

Curtail use of non-recycled consumer and industrial products.

Provide mass transit operating subsidies from the highway trust fund.

Grant air pollution variances only as a last resort if energy conservation measures fail.

Expand deep mining rather than surface mining of coal.

Do not speed up licensing of nuclear power plants.

Expedite anti-trust action against the major oil companies.

CURTAIL USE OF THROWAWAY CONSUMER AND INDUSTRIAL PRODUCTS

According to the Council on Environmental Quality (CEQ), technology is available to recover materials from wastes, yet the percentage of recycled versus total materials used is still declining. A CEQ analysis indicates that use of recycled materials instead of virgin materials can significantly reduce energy consumption. For example, making 1,000 tons of steel reinforcing bars from scrap instead of virgin ores takes 74 percent less energy. (It also takes 51 percent less water, creates 86 percent less air pollution emissions, and generates 97 percent less mining wastes.) Presently it costs the U.S. $6 billion annually to discard materials, much of which could be recycled or converted to energy use. The Environmental Protection Agency estimates that energy recovery practiced in urban areas could meet 2 percent of the nation's energy requirements.

One of the most rapidly growing segments of municipal wastes is packaging. Paper, glass, aluminum and other metals, and plastics now account for one third of the total municipal solid waste stream. In Oregon, where mandatory bottle deposit legislation has been in effect since October, 1972, estimates of annual energy savings amount to the equivalent of the needs of two percent of Oregon's population. (Per gallon of beverage, aluminum cans require approximately 6 times as much energy as do returnable bottles.)

PROVIDE MASS TRANSIT OPERATING SUBSIDIES FROM THE HIGHWAY TRUST FUND

Between 1960 and 1970 the U.S. population increased by 13 percent. During the same period, however, the number of registered automobiles increased by 46 percent and the amount of fuel they consumed increased by 59 percent (fuel efficiency of autos decreased by only 4 percent during this period and hence does not account for the increase in fuel consumed). Thus, not only are indi-

viduals buying more cars per capita but they are driving those cars longer distances.

A significant amount of this increased auto use has been prompted by increased highway construction. Engineers have learned that increased expressway mileage induces motorists to drive more than they would without the expressways. Studies indicate that an individual will travel an additional 0.1 mile to drive on one mile of expressway rather than on city streets or older roads. Freeways that make large scale suburbanization possible also encourage people to drive more. Studies in Baltimore found that since the end of the second world war, the average trip length has increased 20 percent, most of which engineers attribute to increased expressway mileage.

Expanded use of mass transit could greatly reduce the 30 percent of U.S. petroleum that is now devoted to automobile travel. Buses and trains use approximately ⅓ to ¼ the energy per passenger mile that automobiles use. It makes little sense to continue to overfinance energy-wasting highways while energy-conserving mass transit systems lose ridership because of a lack of sufficient operating funds. Shifting monies from the highway trust fund would not only increase these operating funds and win riders for mass transit but would also cut down on travel-inducing new expressway construction.

GRANT AIR POLLUTION VARIANCES ONLY AS A LAST RESORT IF ENERGY CONSERVATION MEASURES FAIL

The relaxation of clean air standards must be viewed only as a last resort; reduction of our extravagant uses of the world's energy resources should be first priority.

Ambient air standards established pursuant to the Clean Air Act were based on the incidence of mortality and hospital admissions for circulatory and respiratory diseases during periods of high air pollution. A relaxation of these clean air goals will most assuredly be coupled with a corresponding increase in major adverse health effects. For this reason, among others, easing of air pollution controls must not be viewed as a primary means to deal with the energy crisis. A reduction of energy waste must be the foremost goal since a lower demand for energy will tend to solve the major problems of air pollution and foreign economic dependence, now and for the future.

In some areas, low sulfur fuel will be unavailable this winter, and industries and utilities which have lately converted from coal will have to return to it. If energy conservation measures fail, variances may be granted on a case by case basis, for a fixed period of a year or less. But the return need be but temporary, and every effort should be made to use high sulfur fuel only in those areas where sulfur oxide, particulate, and sulfate levels are low—so that adverse health effects are prevented or minimized. Another alternative might be to lower sulfur restrictions first on those plants that are equipped with pollution control devices.

High-sulfur fuels, the choice of many industries before air pollution laws were passed, are less expensive than lower sulfur content fuels. The savings which accrue to industries using high sulfur fuels as a result of the present scarcity of oil should be used to purchase and install pollution control equipment, so that environmental deterioration will be minimized.

If variances are granted, the Environmental Protection Agency should step up its air quality monitoring efforts to ensure that an adequate record is made of the effects of those variances and to ensure that severe health hazards do not occur.

EXPAND DEEP MINING RATHER THAN SURFACE MINING OF COAL

The Administration programs emphasize production of federal coal, through strip mining in the West, rather than recovery of the plentiful supplies of low-sulfur coal reserves that now can be deep mined in the East.

Forcing American consumers to depend on federally controlled resources in the West would accelerate a shift in capital investments—for gasification plants, power plants, supportive public works—away from the consuming states and to federally owned lands in the Rockies and Northern Plains. The impact of this major regional shift in capital investment would be felt when gasification and liquefaction—new processes for converting coal into gas and oil—make coal a pipeline product that can be transported cheaply.

Low-sulfur, deep-mine coal is abundant in the East. A report prepared for the Appalachian Regional Commission (May, 1973) states that coal from the region can remain economically competitive even in the face of enforced Clean Air Act sulfur standards, increased oil imports, and a ban on mountain strip mining.

Another study (Environmental Policy Center, Sept., 1973), shows that an increase in production from deep mines now operating at partial capacity would add coal tonnage equal to half the strip mined coal consumed by utilities. The United Mine Workers state that the deep mine work force can be expanded within 5 years to absorb almost all strip mine production—if Congress protects the Eastern deep mine industry from subsidized strip-mined federal coal.

On the basis of the calorific of "heat" value of coal, 55 percent of coal reserves lie east of the Mississippi, with the largest reserve of high quality coal being in the Appalachian region. One ton of Appalachian bituminous coal gives 1.36 times the energy output of a ton of Western subbituminous and 1.93 times that of a ton of lignite. The increased transportation and/or transmission losses of energy reduces still further the new energy from the Western reserves.

Moreover, a ton of Western subbituminous coal of 0.7 percent sulfur content will produce the same sulfur emissions for the same energy as 0.96 percent sulfur Appalachian bituminous coal. Similarly, 0.7 percent Western lignite will produce the same sulfur emissions as 1.35 percent sulfur Appalchian bituminous for the same energy output.

DO NOT SPEED UP LICENSING OF NUCLEAR POWER PLANTS

The Administration is pressing the Atomic Energy Commission to accelerate the licensing and construction of nuclear power plants in order to bring them on line within six years instead of the current ten. This would be accomplished by, among other things, eliminating public hearings for up to eighteen months.

The Administration's plan, however, overlooks several recent trends in AEC activity. Licenses which have already been issued are now being modified by the AEC and, in some cases, even taken away as a result of the discovery of unsuspected safety problems. Broad restrictions have been placed, for example, on several nuclear power plants which were using nuclear reactors manufactured by the General Electric Company. One set of restrictions was prompted by the discovery of defects in the plant's nuclear fuel while another set followed the discovery of structural damage inside the reactor (which thereby caused the normal cooling system to be inadequate). These problems have forced some plants to curtail their power output by as much as 50 percent and one plant is completely shut down (Vermont Yankee).

In another instance, it was recently revealed that one complex of plants under construction in Virginia is being built within a few yards of a geologic fault. Due to the potential earthquake hazard, the AEC is now considering terminating the development of these reactor projects even though construction is well under way (one of the plants is more than 90 percent completed).

In addition to specifically curtailing plant construction, the AEC is also in the process of reviewing proposed safety standards which would govern emergency core cooling systems. The standards being recommended by AEC's staff will require broad restrictions on nuclear power plant operation.

The Administration is seeking to undermine the principle of citizen participation in the development of decisions which will directly affect the public. It should be noted that citizen participation in the decisionmaking processes of the Atomic Safety and Licensing Boards has served to improve the safety of nuclear power plants. Dr. James Schlisenger, former Chairman of the AEC, has publicly commended the citizens who intervened in the Indian Point 2 operating license hearings and exposed serious faults in Consolidated Edison's quality assurance program.

The major safety system, the emergency core cooling system (ECCS), has been examined at numerous, lengthy public hearings sponsored by the AEC. It has become apparent that there exists a great deal of disagreement and controversy (even within the AEC itself) over the ability of the ECCS to prevent a release of radiation in the event of a loss-of-coolant accident.

The existing reactor program is also beset with other critical problems. These include the existence of real possibilities of sabotage or theft, the accumulation of radioactive wastes which last for tens or hundreds of thousands of years, and the danger of adverse health effects resulting from low-level radiation.

Many problems are already posed by the operation of the nation's existing nuclear power plants. Increasing their number, especially through a crash construction program, will serve only to worsen these difficulties. Nothing will be gained by ushering in a radioactivity crisis to replace the current energy crisis.

EXPEDIATE ANTI-TRUST ACTION AGAINST THE MAJOR OIL COMPANIES

Twenty oil companies (8 major and 12 smaller) presently control, directly or indirectly, the supplies of oil, natural gas, coal and uranium (and the development of oil shale, tar sands and geothermal steam) in the United States. According to the House Subcommittee on Special Small Business Problems:

"The major oil companies account for approximately 84 percent of the U.S. refining capacity; about 72 percent of the natural gas production and reserve ownership; 30 percent of domestic coal reserves and over 20 percent of domestic coal production capacity; over 50 percent of uranium reserves and 25 percent of the uranium milling capacity. Further, the major oil companies are acquiring oil shale and tar sands as sell as water rights in many areas of the country." Testifying before the Senate Antitrust and Monopoly Subcommittee, former FPC economist Dr. John Wilson stated,

" . . . the top 14 natural gas producers in 1970 were also among the top 15 oil and liquids producers and among the top 17 petroleum refiners. These 14 leading gas producers were also among the largest sellers of gasoline and other refined petroleum products and among the 17 largest sellers of natural gas to interstate pipelines."

Besides this direct control of energy sources, there is also substantial evidence, of mutual interdependence between virtually all of the major firms in the petroleum industry. This interdependence includes joint lease acquisition (bidding combines) banking interlocks, joint ownership of pipelines and gathering systems, joint ownership and production from oil and gas leases, international joint ventures and vertical relationships between the producing, transporting, processing, and marketing sectors of the industry.

This trend toward concentration has increased and has, in fact, been encouraged by the energy, tax, and foreign policies of the Administration. According to a Federal Trade Commission staff study:

"The industry operates much like a cartel with 15 to 20 integrated firms being the beneficiaries of much federal and state policy. Thus, the federal and state governments with the force of law do for the major oil companies that which would be illegal for the companies to do themselves . . .

"The resulting system endangers existing independents, makes new entry difficult or impossible, and yields serious economic losses to American consumers."

Diversity means strength and the capacity to respond to change with minimum disruption. There can be little doubt that the progressive elimination of competition in the energy field has contributed to the present energy crisis.

BASE ENERGY STRATEGIES ON A MORE REALISTIC ENERGY BUDGET AS WELL AS SEEK ENVIRONMENTALLY SOUND ENERGY SOURCES SUCH AS SOLAR POWER AND NUCLEAR FUSION

Despite the panic of government and industry, there is plenty of energy available if it is used properly. Using it properly, though, requires an energy budget that is much more detailed that what is presently available. Beyond the gross figures on amounts of energy used in various industries and for various residential purposes, there linger serious information gaps: the amount of net energy available from various reserves (coal that takes more energy to mine that it yields is a net energy loss while remaining a gross energy gain), increased costs that accrue as extraction of fuels becomes more difficult, the extent to which fossil fuels subsidize more recent and marginal fuel sources (how coal or oil, for example, are used to mine and process nuclear fuels, develop costly plants, store wastes, operate complex safety systems, and so forth), the relationships between urban patterns and natural and man-controlled energy budgets.

There is also little known about the long range possibilities of solar power, nuclear fusion, and other forms of environmentally sound power. If these forms of power are practical, programs to employ them should be accelerated to the maximum extent possible.

MORE ON ENERGY CONSERVATION

Mr. BERING. Mr. Chairman, if I could answer your question on energy conservation, I believe that the National Bureau of Standards and engineers of the Federal Power Commission have an extremely large number of proposals for energy conservation in small business

and industrial areas and that their belief is that we are falling far short of our frontier in terms of energy conservation in those areas, and that the main problem is simply getting that information put into practice by industrial producers and small businessmen. This information, I believe, applies particularly to the area of building construction, to office buildings and homes. I would say that the importance of energy conservation is part of an overall view of energy use, which we as environmental groups have. It seems to differ somewhat from that implied by ERDA as it is presently designed.

In other words, ERDA is aimed at expanding our means of producing energy, without much view of the resources on which these energy-producing systems are based. The problem of discussing safeguards, environmental safeguards, is that if you apply environmental safeguard procedures to a breeder reactor, and still build the breeder reactor, you have not really accomplished very much. What is really at issue here is a fundamental difference in approach to the whole problem of energy. What I would like to discuss, if possible, is the question of nuclear power as the central cornerstone of our present energy research and development budget.

In particular, I think that the central problems are those of the breeder reactor and the plutonium fuel that Mr. Ford discussed, and the availability of uranium fuel—and if I may, I would like to urge the committee to invite testimony from authorities on breeder reactors. As I understand it, the availability of uranium fuel is limited, at economically retrievable levels—and over the next two decades, we are going to reach a point sometime where, without the breeder, we will be experiencing the same crisis with uranium that we are now experiencing with oil.

PLUTONIUM ECONOMY

Therefore, if the present energy research and development program is to produce a long-term solution to the energy crisis, it can only do so if the breeder reactor is succesful. I think that the Atomic Energy Commission would agree that what they are planning to do is create a plutonium economy for the United States, and I would hope that the Congress would take the time to seriously review that plan before establishing ERDA as it is presently designed. If one looks carefully at the implications and dangers of a plutonium economy, it would seem a vastly better choice to develop natural and renewable sources of energy, as would hopefully be the result of the alternative proposal that we have submitted here.

AEC ROLE IN ERDA

Senator RIBICOFF. I gather from what you say that you are deeply concerned over the fact that the Atomic Energy Commission and what they represent will be given such a large role in ERDA.

Does that bother you gentlemen?

Mr. KNIGHT. Yes, Mr. Chairman, because we have a situation where, over the last 20 years, atomic energy has been accelerated at the expense of other energy forms. Each year, R. & D. commitments have been made on the basis of the availability of various technologies, and each year, atomic energy has seemed more advanced and nearer

fruition as a result of similar decisions made the year before. This self-justifying spiral has resulted in a tremendous imbalance in our efforts in energy development. As I understand it, there has been almost no research into coal mine safety over the last 10 or 15 years, and coal mine safety is one of the reasons, we are told, that we should strip mine instead of deep mine. But there has not been the kind of effort in mine safety that has gone into nuclear power.

I think the same is true for solar energy. Solar heating was being installed in Florida in the twenties, and yet it is still at about the same level of development today.

Mr. MESSING. Let me qualify that just a little. If the Nuclear Energy Commission is separated, as proposed, and if that Commission is amended in such a way as Dr. Ford indicated, then the core of the Atomic Energy Commission staff might be suitable for restructuring the core of the new Energy Research and Development Administration.

Mr. KNIGHT. As to your question to Mr. Ford, about what kind of oversight group you could create, or designate to look into nuclear power, I think the Congress has two such organizations at hand right now; the GAO can and does do studies into administration of the nuclear fuel cycle, and I think the new Office of Technology Assessment is ideally suited to provide an independent and unbiased overview of technical questions that have been imbued with political overtones, such as nuclear power. It is still in its infancy, but OTA would be one means by which Congress could inform itself of the technical complexities of nuclear power. This would enable it to make more informed decisions as to what directions our energy efforts should take.

TRANSFER OF WEAPONS DEVELOPMENT

Senator RIBICOFF. Now, I notice that you recommend that AEC's weapons development function should be transferred to the Department of Defense, rather than ERDA. This is a very controversial issue. It seems on the surface that that is what ought to be done. Does that undermine the traditional thought that there should be civilian control over the nuclear weapons program?

Mr. KNIGHT. I am not able to answer that, Senator. I think there are military personnel in that program already, and in the Department of Defense there still would be civilian overview.

Senator RIBICOFF. But it has been pointed out that some of the best gains in the civilian uses of nuclear energy have come from the research that is involved in the weapons programs, and it is almost impossible to separate them.

Mr. KNIGHT. We are not talking about separating them at the lab stage. We are talking about separating the administration. Some of the national labs do contract work for separate contractors already, and I do not see why this could not also be the case here.

STAFFING THE ENERGY PROGRAMS

Senator RIBICOFF. Now, you gentlemen recommend a conflict of interest provision to prohibit industry executives from holding key policy positions in ERDA. Where do you get, in the next month or so, the personnel? I know what the problem is; where do you get the personnel today to run this energy program; where do you get it to

run different programs such as allocation? Where do you go to right now?

Mr. Knight. I am not sure I could answer that.

Senator Ribicoff. Well, this is one of the problems you have. I understand your fears; I share them. Mr. Simon comes in, and he says, I need 250 men right away to give me a hand. Sure, they have waited too long, but that is the past. We have to move on from there. Where do you get the 250 men to come in right away and do the job?

Where do you find them? I mean, who has the experience? I agree with you that there is a great danger in drawing the personnel from the major oil companies, who in many ways played a role in the problem we now face. Where do we get the men now?

Mr. Messing. I think this is an inherent problem in trying to formulate long range policy determinations or ongoing programs under an emergency basis. There is no satisfactory answer to that question on an emergency basis. There should be, though, provisions to protect against, I would say, an ongoing exchange between private industry and R. & D. administration such as this, when executives do come from private industry, serve in an agency such as ERDA, and then return to private industry on a cyclical basis; that is, there should be some protection against this.

The problem in dealing with this on an emergency basis, I think, is impossible for us to answer.

Mr. Knight. I would agree with Mr. Ramey's statement that the level of the Assistant Administrator should be a career professional position, and not a political appointment that is one of the ways you can safeguard against an outside influence, as we are talking about. I agree with Marc on the short term.

Mr. Bering. I would imagine that at least some of the short-term personnel could come from local and State governments. Just as an example, I know that all of the New England States feel that the people in Washington simply do not grasp their needs for the winter, for this winter, and they are complaining right now that they are getting a smaller share than they deserve and need, in terms of heating oil and so forth.

FUEL ALLOCATION

Senator Ribicoff. Well, I pointed that out to Mr. Simon last Thursday, I have gone over it with him, he understands it. He assures me he will look into it.

Now, having dealt with Mr. Simon, I have confidence that he will directly look into this problem from an allocation standpoint, taking into account New England's special problems, and I would feel that I would get faster action being able to go directly to Mr. Simon than I would to pick up somebody that worked in the mayor's office in Keene, N.H., or Bridgeport, Conn., or Boston, Mass.

Mr. Messing. This is one of the differences between setting up the Federal Energy Administration at this time and setting up an Energy Research and Development Administration. I think that, speaking for my own organization, that we are in favor of the establishment of a Federal Energy Administration at this time, as we are in favor of the Petroleum Allocation Act and even, perhaps, the Senate-passed R. & D. bill. What we do not see is the immediate demand or the justification for going ahead with an additional large-scale re-

organization of the Federal energy machinery at this time. It would seem wiser to us to wait at least a year, until we know whether we are knee-deep or neck-deep in the energy emergency situation before undertaking any major restructuring, such as this bill proposes.

Senator RIBICOFF. But is there any question in the minds of the three of you that the energy problem is not short range? I mean, those that are in this field have been talking about it for the past 10 or 20 years. They have practically pinpointed the date now when this would strike us, and that no matter what the Arabs do with their boycott, this is a permanent problem and there has to be a national policy. And the sooner we get going, the better off we are.

It would seem to me, too, that we are in a situation that, whatever we are setting up, I do not believe that ERDA is the say-all and be-all. I am convinced that we are going to have to proceed with a well thought out program for a Department of Energy and Natural Resources. So this would probably be the start of the base of it. But it would be good to get this going. I do not know how much more delay there can be. We have wasted 2 or 3 years now. Should we wait until Congress goes home, or should we start getting this thing off the ground?

Mr. MESSING. I think we feel very strongly that, indeed, we should wait a little longer, and I will explain why very simply. In other legislation which has either been passed in recent weeks or is pending immediately; we have adequate provisions to deal with the energy situation over the next several years.

As you indicated, one of the problems in establishing a new agency such as this is, where do you get the personnel? Perhaps in 2 years or 3 years, the place to get the personnel would be from a Federal Energy Administration, if that is not continued, and if it feeds into this.

We also have a situation where, basically, the research that we are talking about is currently going on. We are not talking about establishing new research programs. We have research programs going on on fission, on fusion in a variety of national laboratories, on solar, on geothermal, on oil shale. We have all of these research programs going on now. We can allow them to develop over the next year without any loss of time toward ultimate development of the resources in 5 or 10 years, and then if energy restructuring seems desirable, as I am sure it will, once we are past this initial wave of reaction to a very immediate emergency, then that would seem a more prudent time to go ahead with restructuring.

PROTECTION FOR THE SMALL INVENTOR

Senator RIBICOFF. Let me ask you to shift gears a little bit. What specific patent rights protection do you recommend for the small inventor, the small entrepreneur, who is working, bringing up ideas. What sort of protection do we give the small man? I am not talking about the General Motors or the Du Ponts.

Mr. KNIGHT. We have some language on this. This is something that Ms. Roosevelt was particularly interested in, and I can only comment on it. I can present more detailed language later.

Senator RIBICOFF. Would you give me some of your recommendations on that?

And you talk also about providing financial support for the small inventor. What do you have in mind? How do we do that? As a Governor, Senator, every day, you get in the mail suggestions and ideas and blueprints, and everybody has got the answer to everything. Now, how do we determine which small inventor has the making of a great idea, and then who do we support?

PURCHASE POWER OF BIG COMPANIES SHUTS OUT COMPETITION

Mr. KNIGHT. Well, we could follow the lead of the National Science Foundation in this area. I think it is about the only Federal entity that does look at and fund, through grants, the projects and the innovations of small inventors, and this kind of effort should be stimulated more. Often, a small inventor will come up with an idea, and sell it to a large company, which will bury it, because it is not in the company's plans. This removes some competition, and I do not think that that is in the national interest for our energy research and development.

As an example, we have had some communications with some gentlemen in Houston who have developed on a small scale, a prototype for a hydrogen boiler that burns hydrogen. They have been offered $2 to $3 million for the patents by several large companies. But they have decided to try and develop it themselves, and they came to us after having no success with any Government agency. They got thrown out of the Lieutenant Governor of Texas' office; he said they were crackpots, and they came to Washington and had no success presenting their idea. I think that providing a technical staff and some sort of entity that would look at ideas like this—and this is not a crackpot idea, because they have been able to generate some private funding.

Senator RIBICOFF. Well, who knows who the crackpot is, and who is not? Who is going to make that determination?

Mr. MESSING. Outside of public safety considerations, I guess you let the market determine that.

Senator RIBICOFF. Well, it is a tragedy, because people do have good ideas, and it is hard to get anybody to listen, as you can appreciate.

Let me ask you. Is there any country in the world that is doing a constructive, sound job on the environment and energy at the same time? Is there anyone that is concerned, or any nation doing an adequate job; a good job?

Mr. MESSING. Oh, I do not think we could speak with authority. I think there are different measures in different countries that show sensibilities toward different areas than others. I would not want to generalize on that.

Senator RIBICOFF. In other words, the whole field is wide open?

Mr. MESSING. Well, we can look at one example. Japan has traditionally lived on a very marginal resource and energy basis. They have managed to increase their quality of life in recent years, and their gross national product, but still with a very small margin of error in it. I was told several days ago by a representative of one of the major utility equipment manufacturers that, on a recent trip to Japan he had gone there to see how American equipment was being utilized to

keep the air clean, and he had particularly wanted to see how the SO_2 scrubbers were working, because utilities in this country have found that, in their experience, you cannot maintain these, you cannot keep them clean, they are more a problem than they are worth. He found that in Japan, they are making the scrubbers work. They are keeping the scrubbers clean, and they are keeping the air at a marginally acceptable level. But in Japan they are making American equipment perform.

On the other hand, Japan is entirely dependent on the sea, or very largely dependent on the sea, for its protein base, and in this area it is falling behind. While in one area they are doing their best to keep their head above water; in another area, where the threat is not as visible they are unable to do the same thing. It is a matter of national incentives.

Senator Ribicoff. Let me ask you one final question.

Working in the environmental field as you do, are you pessimistic or optimistic about what you are trying to achieve today?

Mr. Messing. I have no choice but to be optimistic.

Senator Ribicoff. In other words, you are concerned, worried?

Mr. Messing. Absolutely.

Mr. Bering. I think there is an extremely good basis for optimism if the renewable resources of energy are developed while we still have the fossil fuel potential to carry out that development. If we do not do that, then I think that the pessimistic conclusions that are extremely serious, because it is very possible that we will spend our entire savings account before we get around to building our house. And I think we are at a point of very profound choice in our national history, and if we go one way it is going to be great, and if we go the other way it is going to be very, very gloomy.

BLESSING IN DISGUISE

Senator Ribicoff. I personally feel that we are in the watershed period of American society, that this is in many ways a blessing in disguise, and there is so much that we can achieve if we have the will and commitment to do so and not panic.

I want to thank you gentlemen for coming here. Many of your suggestions are very constructive. Whether we can translate them into legislation or not, I do not know. But you do have some good ideas, and I like many of your ideas. Thank you very much for being with us today.

The committee will stand adjourned until further call by the Chair.

[Whereupon, at 12:30 p.m., the subcommittee was adjourned, subject to the call of the Chair.

APPENDIX

[S. 2744, 93d Cong., 1st sess.]

A BILL To reorganize and consolidate certain functions of the Federal Government in a new Energy Research and Development Administration and in a Nuclear Energy Commission in order to promote more efficient management of such functions.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE

SECTION 1. This Act may be cited as the "Energy Reorganization Act of 1973".

SEC. 2. (a) The Congress hereby declares that the general welfare and the common defense and security require effective action to develop, and increase the efficiency and reliability of use of all energy sources to meet the needs of present and future generations, to increase the productivity of the national economy and strengthen its position in regard to international trade, to make the Nation self-sufficient in energy, and to advance the goals of restoring, protecting, and enhancing environmental quality.

(b) The Congress finds that, to best achieve these objectives, improve Government operations, and assure the coordinated and effective development of all energy sources, it is necessary to establish an Energy Research and Development Administration to bring together and direct Federal activities relating to research and development on the various sources of energy, to increase the efficiency and reliability in the use of energy, and to carry out the performance of other functions, including military and production activities.

(c) The Congress further declares and finds that it is in the public interest that the licensing and related regulatory functions of the Atomic Energy Commission be separated from the performance of the other functions of the Commission transferred pursuant to this Act, and that this separation be effected in an orderly manner assuring adequacy of technical and other resources necessary for the performance of each.

TITLE I—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

ESTABLISHMENT

SEC. 101. There is hereby established an independent executive agency to be known as the Energy Research and Development Administration (hereinafter in this Act referred to as the "Administration").

OFFICERS

SEC. 102. (a) There shall be at the head of the Administration an Administrator of Energy Research and Development (hereinafter in this Act referred to as the "Administrator"), who shall be appointed by the President, by and with the advice and consent of the Senate. The Administrator shall receive compensation at the rate now or hereafter prescribed for offices and positions at level II of the Executive Schedule (5 U.S.C. 5313). The Administration shall be administered under the supervision and direction of the Administrator, who shall be responsible for the efficient and coordinated management of the Administration.

(b) There shall be in the Administration a Deputy Administrator who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall receive compensation at the rate now or hereafter prescribed for offices and positions at level III of the Executive Schedule (5 U.S.C. 5314).

(c) There shall be in the Administration five Assistant Administrators, one of whom shall be responsible for fossil energy, another for nuclear energy, another for environment, safety, and conservation, another for research and advanced energy, and another for national security. The Assistant Administrators shall be appointed by the President, by and with the advice and consent of the Senate, and shall receive compensation at the rate now or hereafter prescribed for offices and positions at level IV of the Executive Schedule (5 U.S.C. 5315).

(d) There shall be in the Administration a General Counsel who shall be appointed by the Administrator and who shall serve at the pleasure of and be removable by the Administrator. The General Counsel shall receive compensation at the rate now or hereafter prescribed for offices and positions at level V of the Executive Schedule (5 U.S.C. 5316).

(e) There shall be in the Administration not more than seven additional officers appointed by the Administrator who shall receive compensation at the rate now or hereafter prescribed for offices and positions at level V of the Executive Schedule (5 U.S.C. 5316). The positions of such offices shall be considered career positions and be subject to subsection 161d of the Atomic Energy Act.

(f) The Division of Military Application transferred to and established in the Administration by section 104(a) of this Act shall be under the direction of a Director of Military Application, who shall be appointed by the Administrator and who shall serve at the pleasure of and be removable by the Administrator and shall be an active commissioned officer of the Armed Forces serving in general or flag officer rank or grade. The functions, qualifications, and compensation of the Director of Military Application shall be the same as those provided under the Atomic Energy Act of 1954, as amended, for the Assistant General Manager for Military Application.

(g) Officers appointed pursuant to this section shall perform such functions as the Administrator shall specify from time to time.

(h) The Deputy Administrator (or in the absence or disability of the Deputy Administrator, or in the event of a vacancy in the office of the Deputy Administrator, an Assistant Administrator, the General Counsel or such other official, determined according to such order as the Administrator shall prescribe) shall act for and perform the functions of the Administrator during any absence or disability of the Administrator or in the event of a vacancy in the office of the Administrator.

FUNCTIONS

SEC. 103. The functions of the Administrator shall include, but not be limited to—

(1) exercising central responsibility for policy planning, coordination, support, and management of research and development programs respecting all energy sources, including assessing the requirements for research and development in regard to various energy sources in relation to near-term and long-range needs, policy planning in regard to meeting those requirements, undertaking programs for the optimal development of the various forms of energy sources, managing such programs, and disseminating information resulting therefrom;

(2) encouraging and conducting research and development to demonstrate the commercial feasibility of energy sources and utilization technologies;

(3) undertaking research and development in the extraction, conversion, transmission, and utilization phases related to the development and use of energy from fossil, nuclear, solar, geothermal, and other energy sources;

(4) engaging in and supporting environmental biomedical, physical, and safety research related to the development of energy sources and utilization technologies;

(5) ascertaining the existence, progress, and results of other public and private research and development activities relevant to the Administration's mission and correlating its own research and development programs with such public and private activities;

(6) participating in and supporting cooperative research and development projects which may involve contributions by public or private persons or agencies, of financial or other resources to the performance of the work; and

(7) developing, collecting, distributing, and making available for distribution, scientific and technical information concerning the manufacture or development of energy and its efficient extraction, conversion, transmission, and utilization.

TRANSFER OF FUNCTIONS

SEC. 104. (a) There are hereby transferred to and vested in the Administrator all functions of the Atomic Energy Commission, the Chairman and members of the Commission, and the officers and components of the Commission, except as otherwise provided in this Act. The General Advisory Committee established pursuant to section 26 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2036), the Military Liaison Committee established by section 27 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2037), the Patent Compensation

Board established pursuant to section 157 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2187), and the Division of Military Application established by section 25 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2035), are transferred to the Energy Research and Development Administration and the functions of the Commission with respect thereto are transferred to the Administrator.

(b) There are hereby transferred to and vested in the Administrator such functions of the Secretary of the Interior, the Department of the Interior, and officers and components of such department—

(1) as related to or are utilized by the Office of Coal Research established pursuant to the Act of July 1, 1960 (74 Stat. 336; 30 U.S.C. 661–668);

(2) as relate to or are utilized in connection with fossil fuel energy research and development programs and related activities conducted by the Bureau of Mines "energy centers" and synthane plant to provide greater efficiency in the extraction, processing, and utilization of energy resources for the purpose of conserving those resources, developing alternative energy resources such as oil and gas secondary and tertiary recovery, oil shale and synthetic fuels, improving methods of managing energy-related wastes and pollutants, and providing technical guidance needed to establish and administer national energy policies; and

(3) as relate to or are utilized for underground electric power transmission research.

(c) There are hereby transferred to and vested in the Administrator such functions of the National Science Foundation as relate to or are utilized in connection with—

(1) solar heating and cooling development; and

(2) geothermal power development.

(d) There are hereby transferred to and vested in the Administrator such functions of the Environmental Protection Agency and the officers and components thereof as relate to or are utilized in connection with—

(1) the development and demonstration of alternative automotive power systems; and

(2) the development and demonstration of precombustion, combustion, and postcombustion technologies to control emissions of pollutants from stationary sources using fossil fuels.

(e) To the extent necessary or appropriate to perform functions and carry out programs transferred by this Act, the Administrator may exercise, in relation to the functions so transferred, any authority or part thereof available by law, including appropriation Acts, to the official or agency from which such functions were transferred.

TRANSFER OF PERSONNEL AND OTHER MATTERS

SEC. 105. (a) Except as provided in the next sentence, the personnel employed in connection with, and the personnel, positions, assets, liabilities, contracts, property, records, and unexpended balances of appropriations, allocations, and other funds employed, held, used, arising from, available to or to be made available in connection with the functions and programs transferred by this Act, are, subject to section 202 of the Budget and Accounting Procedures Act of 1950 (31 U.S.C. 581c), correspondingly transferred for appropriate allocation. Personnel positions expressly created by law, personnel occupying those positions on the effective date of this Act, and personnel authorized to receive compensation at the rate prescribed for offices and positions at levels II, III, IV, or V of the Executive Schedule (5 U.S.C. 5313–5316) on the effective date of this Act shall be subject to the provisions of subsection (c) of this section and section 301 of this Act.

(b) Except as provided in subsection (c), transfer of nontemporary personnel pursuant to this Act shall not cause any such employee to be separated or reduced in grade or compensation for one year after such transfer.

(c) Any person who, on the effective date of this Act, held a position compensated in accordance with the Executive Schedule prescribed in chapter 53 of title 5 of the United States Code, and who, without a break in service, is appointed in the Administration to a position having duties comparable to those performed immediately preceding his appointment shall continue to be compensated in his new position at not less than the rate provided for his previous position.

ADMINISTRATIVE PROVISIONS

Sec. 106. (a) The Administrator is authorized to prescribe such policies, standards, criteria, procedures, rules, and regulations as he may deem to be necessary or appropriate to perform functions now or hereafter vested in him.

(b) The Administrator shall engage in such policy planning, and perform such program evaluation analyses and other studies, as may be necessary to promote the efficient and coordinated administration of the Administration and properly assess progress toward the achievement of its missions.

(c) Except as otherwise expressly provided by law, the Administrator may delegate any of his functions to such officers and employees of the Administration as he may designate, and may authorize such successive redelegations of such functions as he may deem to be necessary or appropriate.

(d) Except as provided in section 102, the Administrator may organize the Administration as he may deem to be necessary or appropriate.

(e) The Administrator is authorized to establish, maintain, alter, or discontinue such State, regional, district, local, or other field offices as he may deem to be necessary or appropriate to perform functions now or hereafter vested in him.

(f) The Administrator shall cause a seal of office to be made for the Administration of such device as he shall approve, and judicial notice shall be taken of such seal.

(g) The Administrator is authorized to establish a working capital fund, to be available without fiscal year limitation, for expenses necessary for the maintenance and operation of such common administrative services as he shall find to be desirable in the interests of economy and efficiency. There shall be transferred to the fund the stocks of supplies, equipment, other assets, liabilities, and unpaid obligations relating to the services which he determines will be performed through the fund. Appropriations to the fund, in such amounts as may be necessary to provide additional working capital, are authorized. The working capital fund shall recover, from the appropriations and funds for which services are performed, either in advance or by way of reimbursement, amounts which will approximate the costs incurred, including the accrual of annual leave and the depreciation of equipment. The fund shall also be credited with receipts from the sale or exchange of its property, and receipts in payment for loss or damage to property owned by the fund.

PERSONNEL

Sec. 107. (a) The Administrator is authorized to select, appoint, employ, and fix the compensation of such officers and employees, including attorneys, pursuant to section 161d of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2201(d)) as are necessary to perform the functions now or hereafter vested in him and to prescribe their functions.

(b) The Administrator is authorized to obtain services as provided by section 3109 of title 5 of the United States Code.

(c) The Administrator is authorized to provide for participation of military personnel in the performance of his functions. Members of the Army, the Navy, the Air Force, or the Marine Corps may be detailed for service in the Administration by the appropriate military Secretary, pursuant to cooperative agreements with the Secretary, for service in the Administration in positions other than a position the occupant of which must be approved by and with the advice and consent of the Senate.

(d) Appointment, detail, or assignment to, acceptance of, and service in, any appointive or other position in the Administration under this section shall in no way affect the status, office, rank, or grade which such officers or enlisted men may occupy or hold, or any emolument, perquisite, right, privilege, or benefit incident to or arising out of any such status, office, rank, or grade. A member so appointed, detailed, or assigned shall not be subject to direction or control by his armed force, or any officer thereof, directly or indirectly, with respect to the responsibilities exercised in the position to which appointed, detailed, or assigned.

(e) The Administrator is authorized to pay transportation expenses, and per diem in lieu of subsistence expenses, in accordance with chapter 57 of title 5 of the United States Code for travel between places of recruitment and duty, and while at places of duty, of persons appointed for emergency, temporary, or seasonal services in the field service of the Administration.

POWERS

SEC. 108. (a) The Administrator is authorized to exercise his powers in such manner as to insure the continued conduct of research and development and related activities in areas or fields deemed by the Administrator to be pertinent to the acquisition of an expanded fund of scientific, technical, and practical knowledge in energy matters. To this end, the Administrator is authorized to make arrangements (including contracts, agreements, and loans) for the conduct of research and development activities with private or public institutions or persons, including participation in joint or cooperative projects of a research, developmental, or experimental nature; to make payments (in lump sum or installments, and in advance or by way of reimbursement, with necessary adjustments on account of overpayments or underpayments); and generally to take such steps as he may deem necessary or appropriate to perform functions now or hereafter vested in him. Such functions of the Administrator under this Act as are applicable to the nuclear activities transferred pursuant to this title shall be subject to the provisions of the Atomic Energy Act of 1954, as amended, and to other authority applicable to such nuclear activities. The nonnuclear functions of the Administrator referred to in sections 103 and 104 of this Act shall be carried out pursuant to the provisions of this Act, applicable authority existing immediately before the effective date of this Act, or in accordance with the provisions of chapter 4 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2051–2053).

(b) Except for public buildings as defined in the Public Buildings Act of 1959, as amended, and with respect to leased space subject to the provisions of Reorganization Plan Numbered 18 of 1950, the Administrator is authorized to acquire (by purchase, lease, condemnation, or otherwise), construct, improve, repair, operate, and maintain facilities and real property as the Administrator deems to be necessary in and outside of the District of Columbia. Such authority shall apply only to facilities required for the maintenance and operation of laboratories, research and testing sites and facilities, quarters, and related accommodations for employees and dependents of employees of the Administration, and such other special-purpose real property as the Administrator deems to be necessary in and outside the District of Columbia. Title to any property or interest therein, real, personal, or mixed, acquired pursuant to this section, shall be in the United States.

(c)(1) The Administrator is authorized to provide, construct, or maintain, as necessary and when not otherwise available, the following for employees and their dependents stationed at remote locations:

(A) emergency medical services and supplies;

(B) food and other subsistence supplies;

(C) messing facilities;

(D) audiovisual equipment, accessories, and supplies for recreation and training;

(E) reimbursement for food, clothing, medicine, and other supplies furnished by such employees in emergencies for the temporary relief of distressed persons;

(F) living and working quarters and facilities; and

(G) transportation for school-age dependents of employees to the nearest appropriate educational facilities.

(2) The furnishing of medical treatment under subparagraph (A) of paragraph (1) and the furnishing of services and supplies under paragraphs (B) and (C) of paragraph (1) shall be at prices reflecting reasonable values as determined by the Administrator.

(3) Proceeds from reimbursements under this section shall be deposited in the Treasury and may be withdrawn by the Administrator to pay directly the cost of such work or services, to repay or make advances to appropriations or funds which do or will bear all or a part of such cost, or to refund excess sums when necessary; except that such payments may be credited to a service or working capital fund otherwise established by law, and used under the law governing such funds, if the fund is available for use by the Administrator for performing the work or services for which payment is received.

(d) The Administrator is authorized to acquire any of the following described rights if the property acquired thereby is for use in, or is useful to, the performance of functions vested in him:

(1) copyrights, patents, and applications for patents, designs, processes, and manufacturing data;

(2) licenses under copyrights, patents, and applications for patents; and

(3) releases, before suit is brought, for past infringement of patents or copyrights.

(e) With respect to all nonnuclear research and development, including demonstration projects, contracted for, sponsored, or cosponsored by the Administration pursuant to this Act, the applicable arrangement shall provide that the disposition of patent rights in inventions or discoveries arising out of the work under the arrangement shall be governed by the President's Statement of Government Patent Policy issued on August 23, 1971 (36 F.R. 16887, August 26, 1971) and amended in September 1973 (38 F.R. 23782, September 4, 1973): *Provided*, That the Administrator in administering such patents shall make a determination, on a case-by-case basis, as to whether a requested license shall be granted on a royalty-free basis or upon a basis of charges designed to recover part or all of the costs of the research and development.

(f) Subject to the provisions of chapter 12 of the Atomic Energy Act (42 U.S.C. 2161–2166), and other applicable law, the Administrator shall disseminate scientific, technical, and practical information acquired pursuant to this title through information programs and other appropriate means, and shall encourage the dissemination of scientific, technical, and practical information relating to energy so as to enlarge the fund of such information and to provide that free interchange of ideas and criticism which is essential to scientific and industrial progress and public understanding.

(g) The Administrator is authorized to accept, hold, administer, and utilize gifts, and bequests of property, both real and personal, for the purpose of aiding or facilitating the work of the Administration. Gifts and bequests of money and proceeds from sales of other property received as gifts or bequests shall be deposited in the Treasury and shall be disbursed upon the order of the Administrator. For the purposes of Federal income, estate, and gift taxes, property accepted under this section shall be considered as a gift or bequest to the United States.

Title II—Nuclear Energy Commission

CHANGE IN NAME

Sec. 201. The Atomic Energy Commission is hereby renamed the Nuclear Energy Commission and shall continue to perform the licensing and related regulatory functions of the Chairman and members of the Commission, the general counsel, and other officers and components of the Commission, which functions, officers, components, and personnel are excepted from the transfer to the Administrator by section 104(a) of this Act.

LICENSING OF SELECTED ADMINISTRATION FACILITIES

Sec. 202. Notwithstanding the exclusions provided for in section 110a or any other provisions of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2140 (a)), the Nuclear Energy Commission shall, except as otherwise specifically provided by section 110b of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2140 (b)), or other law, have licensing authority pursuant to chapters 6, 7, 8, 10, and section 185, of the Atomic Energy Act of 1954, as amended, as to the following facilities of the Administration:

(1) demonstration liquid metal fast breeder reactors when operated as part of the power generation facilities of an electric utility system;

(2) other demonstration nuclear reactors when operated as part of the power generation facilities of an electric utility system, except those in existence, under construction or authorized or appropriated for by the Congress on the date this part becomes effective; or

(3) facilities used primarily for the receipt and storage of high level radioactive wastes resulting from activities licensed under such Act, except those in existence, under construction, or authorized or appropriated for by the Congress, on the date this Act becomes effective.

RESEARCH

Sec. 203. (a) The Nuclear Energy Commission may engage in or contract for research which the Commission deems necessary for the discharge of its licensing and regulatory functions.

(b) In order to achieve the objectives and carry out the purposes of subsection (a), the Energy Research and Development Administration and all other Federal agencies shall, to the extent practicable—

(1) cooperate with respect to the establishment of priorities for the furnishing of such research services requested by the Nuclear Energy Commission as the Commission deems necessary for the conduct of its functions; and

(2) furnish to the Nuclear Energy Commission, when requested, on a reimbursable basis, through its own facilities or by contract or other arrangement, such research services as the Commission deems necessary for the conduct of its functions.

Title III—Miscellaneous and Transitional Provisions

transitional provisions

Sec. 301. (a) Except as otherwise provided in this Act, whenever all of the functions or programs of an agency, or other body, or any component thereof, affected by this Act, have been transferred from that agency, or other body, or any component thereof by title I of this Act, the agency, or other body, or component thereof shall lapse. If an agency, or other body, or any component thereof, lapses pursuant to the preceding sentence, each position and office therein which was expressly authorized by law, or the incumbent of which was authorized to receive compensation at the rate prescribed for an office or position at level II, III, IV, or V of the Executive Schedule (5 U.S.C. 5313–5316), shall lapse.

(b) All orders, determinations, rules, regulations, permits, contracts, certificates, licenses, and privileges—

(1) which have been issued, made, granted, or allowed to become effective by the President, any Federal department or agency or official thereof, or by a court of competent jurisdiction, in the performance of functions which are transferred under this Act, and

(2) which are in effect at the time this Act takes effect,

shall continue in effect according to their terms until modified, terminated, superseded, set aside, or revoked by the President, the Administrator, or other authorized officials, a court of competent jurisdiction, or by operation of law.

(c) The provisions of this Act shall not affect any proceeding pending, at the time this section takes effect, before any department or agency (or component thereof) functions of which are transferred by this Act; but such proceedings, to the extent that they relate to functions so transferred, shall be continued. Orders shall be issued in such proceedings, appeals shall be taken therefrom, and payments shall be made pursuant to such orders, as if this Act had not been enacted; and orders issued in any such proceedings shall continue in effect until modified, terminated, superseded, or revoked by a duly authorized official, by a court of competent jurisdiction, or by operation of law. Nothing in this subsection shall be deemed to prohibit the discontinuance or modification of any such proceeding under the same terms and conditions and to the same extent that such proceeding could have been discontinued if this Act had not been enacted.

(d) Except as provided in subsection (f)—

(1) the provisions of this Act shall not affect suits commenced prior to the date this Act takes effect, and,

(2) in all such suits proceedings shall be had, appeals taken, and judgments rendered, in the same manner and effect as if this Act had not been enacted.

(e) No suit, action, or other proceeding commenced by or against any officer in his official capacity as an officer of any department or agency, functions of which are transferred by this Act, shall abate by reason of the enactment of this Act. No cause of action by or against any department or agency, functions of which are transferred by this Act, or by or against any officer thereof in his official capacity shall abate by reason of the enactment of this Act. Causes of actions, suits, actions, or other proceedings may be asserted by or against the United States or such official as may be appropriate and, in any litigation pending when that section takes effect, the court may at any time, on its own motion or that of any party, enter any order which will give effect to the provisions of this section.

(f) If, before the date on which this Act takes effect, any department or agency, or officer thereof in his official capacity, is a party to a suit, and under this Act any function of such department, agency, or officer is transferred to the Administrator, or any other official, then such suit shall be continued as if this Act had not been enacted, with the Administrator, or other official, as the case may be, substituted.

(g) Final orders and actions of any official or component in the performance of functions transferred by this Act shall be subject to judicial review to the same extent and in the same manner as if such orders or actions had been made or

taken by the officer, department, agency, or instrumentality in the performance of such functions immediately preceding the effective date of this Act. Any statutory requirements relating to notices, hearings, action upon the record, or administrative review that apply to any function transferred by this Act shall apply to the performance of those functions by the Administrator, or any officer or component.

(h) With respect to any function transferred by this Act and performed after the effective date of this Act, reference in any other law to any department or agency, or any officer or office, the functions of which are so transferred, shall be deemed to refer to the Administrator, or other officials in which this Act vests such functions.

(i) Nothing contained in this Act shall be construed to limit, curtail, abolish, or terminate any function of the President which he had immediately before the effective date of this Act; or to limit, curtail, abolish, or terminate his authority to perform such function; or to limit, curtail, abolish, or terminate his authority to delegate, redelegate, or terminate any delegation of functions.

(j) Any reference in this Act to any provision of law shall be deemed to include, as appropriate, references thereto as now or hereafter amended or supplemented.

(k) Except as may be otherwise expressly provided in this Act, all functions expressly conferred by this Act shall be in addition to and not in substitution for functions existing immediately before the effective date of this Act and transferred by this Act.

INCIDENTAL DISPOSITIONS

SEC. 302. The Director of the Office of Management and Budget is authorized to make such additional incidental dispositions of personnel, personnel positions, assets, liabilities, contracts, property, records, and unexpended balances of appropriations, authorizations, allocations, and other funds held, used, arising from, available to or to be made available in connection with functions transferred by this Act, as he may deem necessary or appropriate to accomplish the intent and purpose of this Act.

DEFINITIONS

SEC. 303. As used in this Act—

(1) any reference to "function" or "functions" shall be deemed to include references to duty, obligation, power, authority, responsibility, right, privilege, and activity, or the plural thereof, as the case may be; and

(2) any reference to "perform" or "performance", when used in relation to functions shall be deemed to include the exercise of power, authority, rights, and privileges.

AUTHORIZATION FOR APPROPRIATIONS

SEC. 304. Except as otherwise provided by law, appropriations made under this Act shall be subject to annual authorization.

COMPTROLLER GENERAL AUDIT

SEC. 305. Section 166 "Comptroller General Audit" of the Atomic Energy Act of 1954, as amended, shall be deemed to be applicable, respectively, to the nuclear and nonnuclear activities under title I and to the activities under title II.

SEPARABILITY

SEC. 306. If any provision of this Act, or the application thereof to any person or circumstance, is held invalid, the remainder of this Act, and the application of such provision to other persons or circumstances, shall not be affected thereby.

EFFECTIVE DATE AND INTERIM APPOINTMENT

SEC. 307. (a) The provisions of this Act shall take effect one hundred and twenty days after the Administrator first takes office, or on such earlier date as the President may prescribe and publish in the Federal Register; except that any of the officers provided for in title II of this Act may be nominated and appointed, as provided in that title, at any time after the date of enactment of this Act. Funds available to any department or agency (or any official or component thereof), any functions of which are transferred to the Administrator by this Act, may, with the approval of the President, be used to pay the compensation and expenses of any officer appointed pursuant to this subsection until such time as funds for that purpose are otherwise available.

(b) In the event that any officer required by this Act to be appointed by and with the advice and consent of the Senate shall not have entered upon office on the effective date of this Act, the President may designate any officer, whose appointment was required to be made by and with the advice and consent of the Senate and who was such an officer immediately prior to the effective date of this Act, to act in such office until the office is filled as provided in this Act. While so acting, such persons shall receive compensation at the rates provided by this Act for the respective offices in which they act.

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., December 7, 1973.

Hon. ABRAHAM A. RIBICOFF,
Chairman, Subcommittee on Reorganization, Research and International Organizations, Committee on Government Operations, U.S. Senate, Washington, D.C.

DEAR SENATOR RIBICOFF: Your invitation to Dr. Stever to testify on S. 2744 arrived during his absence from the country to serve as U.S. Chairman at the second meeting of the US-USSR Joint Commission on Scientific and Technical Cooperation in Moscow. I know that he feels strongly about the importance of this legislation in relation to the critical energy problems confronting us. He has expressed his regret at not being able to testify before your committee, as he did in response to a similar invitation from the Committee on Government Operations in the House of Representatives. As Dr. Stever very much hopes the views of the Foundation can be made a part of the record, I am setting forth below the statement he approved for submission to the House committee before leaving on his trip.

Energy R&D policy objectives provide the driving force behind investment in energy R&D. The formulation of our present and future energy R&D program should be based on the following major policy objectives set forth by the President for "Project Independence":

1. Provision of the Nation with adequate energy at a minimum cost.
2. Development of a national energy system having minimal impact on the environment.
3. Development of an energy system of high reliability and maximum security against natural disaster and acts of war or sabotage.
4. Achievement of a capability for energy self-sufficiency by the end of this decade.

In order to achieve these policy objectives, the Administration is recommending a major increase in our national energy research and development program to a level of expenditure of at least $10 billion cumulative over the next five-year period. In executing and administering such a program, it is vital to take into account the complexity of our national energy system, with its many components involved in the production, distribution, and use of energy. It is most important that proposed projects or areas in energy R&D be examined and evaluated from a total systems point of view. This can best be accomplished by the creation of a new independent agency, the Energy Research and Development Agency (ERDA) as proposed in S. 2744. Such an agency would provide the coherent direction necessary both for the formulation of effective policy in these complex areas, and for the development and implementation of the required major new technologies. I would expect that ERDA, in the performance of these functions, would, where indicated for best overall program execution, utilize the laboratory and research facilities of other Federal agencies, such as NASA and DOD, as well as those of private industry.

One principal mission of the National Science Foundation is to support basic research in all fields of science and to maintain the health of science in the United States, which includes insuring a strong cadre of manpower in science and engineering. Many of the fields of basic research contribute directly to the energy R&D which is now being discussed. Let me illustrate this important fact.

Any of the energy technologies proposed will benefit in both the short- and long-term from deeper understanding of the phenomena on which they are based. Coal gasification plants depend upon improvements in catalysis, organic chemistry, sulphur chemistry, chemical kinetics, thermodynamics, and materials. The success of fusion reactors will depend on behavior of plasmas under conditions not yet established in the laboratory. The impacts of various energy supply and utilization patterns on people, economics, and the environment are of the utmost importance, but we now lack the understanding needed to make sound predictions. High temperature gas turbines, attractive for coupling to gas-cooled reactors, depend on unknown behavior of materials subjected to mechanical and thermal stresses in helium atmosphere with parts per million of nitrogen, carbon monoxide, carbon dioxide, and water. Hydrogen proposed as the clean fuel might be produced

economically by mimicking photosynthesis or by vastly accelerating thermochemical reactions which are now impractically slow. Fluid dynamics and heat and mass transport must be further researched to improve the behavior of heat exchangers, building insulation, and cooling towers and their plumes. Biological effects of trace amounts of toxic substances and the movement and concentration of these substances through the environment must be understood.

NSF expects to continue this basic research role, cooperating fully with the new ERDA in the discharge of its overall energy research and development responsibilities.

Proof-of-concept for new alternative sources of energy is strongly dependent on an effective linkage with basic research. The unique relationship of the NSF with the Nation's universities provides an exceptionally efficient means of bringing the best new ideas forward, designing the needed energy research, and establishing proof-of-concept tests of these ideas. These relationships have proven to be effective in providing options for future development. This development would be carried out by ERDA.

Recognizing the need for energy research of this type, the Foundation has actively supported research on solar, geothermal and other advanced systems concepts for helping to meet national energy needs. Because our activities in these areas have a bearing on the relationship of the Foundation to ERDA, I believe a brief review at this point will help provide some background useful for your consideration.

The overall objective of the NSF research in solar energy is to establish the potential of solar energy as an alternative energy source at the earliest feasible time. Although Federal support for research on terrestrial application of solar energy extends at least as far back as 1950, the first sizable Federal effort to investigate the practical uses of solar energy in meeting our domestic needs may be dated from FY 1971 when NSF obligated more than $1 million for solar energy support. Since that time the pace of events has increased rapidly with universities, complemented by industries, national laboratories, and other institutions mobilized in a program aimed at proof-of-concept experiments. Details of this effort appear in a tabulation of NSF solar energy research grants in FY 1973 and FY 1974 to date, which I attach to this letter. Funding for solar energy research by the NSF has increased, through its Research Applied to National Needs (RANN) program, to an expected level of $13.2 million in FY 1974, and we expect further growth to occur next year.

Thus, NSF has played the key role in the national research efforts which are designed to lead to the domestic use of solar energy as soon as possible. Because of our active role in sponsoring research on terrestrial uses of solar energy, the Foundation is well on its way to carrying out a carefully-organized, fast-paced plan which is designed to bring solar heating and cooling systems for buildings through the proof-of-concept phase to the development, demonstration and commercial design stages in 1975. It is planned that ERDA will take over responsibility for the program in these stages. At the same time that NSF is moving to the initiation of system proof-of-concept experiments, we are also working to obtain improved efficiency and reduced cost of various technological components out of which such systems would be constructed.

In the area of geothermal energy, the Foundation maintains a smaller but incisive program to assess and prove the potential of geothermal energy as an energy resource. As you know, the only large scale geothermal power-generating complex in the U.S. is the Geysers field in northern California. But the Geysers complex utilizes dry steam, which is a rare phenomenon and is unlikely to become a major factor in the U.S. energy system. If we are to exploit geothermal energy, we must work with more prevalent types of geothermal resources, but unfortunately they are not as easy to convert to economic sources of energy. The most abundant of the potential sources of geothermal energy are hot brines and hot rock. While they have the advantage of being more abundant, they are also the hardest of the geothermal resources to utilize.

Much of the technology required to exploit these sources still needs to be developed, and the geothermal research program undertaken by the Foundation has focused on learning more about these types of resources and how best to exploit them. We are hopeful that we will be successful in these undertakings which could lead to large scale hot brine power plants being designed and constructed in this decade. If efforts in rock-fracturing now underway are successful, power plants using hot rock resources could be on line by the next decade. In the pursuit of these practical objectives, we are not neglecting the potential impact of these new technologies and we are studying the legal, economic, and

environmental aspects of such technological developments. It is planned that ERDA will take over responsibility for the geothermal program in the development, demonstration and commercial design stages.

In addition to its research support activities for solar and geothermal energy the Foundation is also active in other aspects of energy research. These include research to:

Analyze and synthesize alternative means of meeting U.S. energy requirements while satisfying economic and environmental quality constraints.

Discover methods for more effectively managing and utilizing conventional energy resources and new or modified energy resources.

Improve methods to convert energy to a form which is practical for transmission and use.

Discover novel power transmission concepts to transport energy from current and new production sources to consumption sites, and apply computer methods to operate, plan, model, and optimize these systems.

We recognize and support the many persuasive reasons for establishing an Energy Research and Development Administration that is capable of coordinating and funding research on all energy sources. At the same time we believe that it is important for NSF to continue to support research on advanced energy concepts in selected areas. This is essential to supplement the work of ERDA by assuring that all avenues of research to deal with our long-range energy problems are full explored.

Research through proof-of-concept experiments is intended to provide the assurance we need to make prudent and wise choices. During these early stages it is essential that new ideas be encouraged and evaluated as a basis for selecting candidates for prototype development, large scale demonstration, and commercialization. We believe that the Foundation is especially qualified to carry out the early stages of this type of work because it has no institutional mission to preserve, has extensive ties with the research community, and is experienced in managing large interdisciplinary undertakings.

When programs reach the developmental and demonstration stages we believe that they should be taken over by the appropriate mission agency or user groups such as private industry. In this regard, we believe it entirely appropriate that the proposed Energy Research and Development Administration undertake the management of all energy R&D programs after proof-of-concept has been established. In cooperation with industry, ERDA could apply its resources to large scale implementation programs which have a high probability of success. Such an arrangement would have the added advantage of giving the Foundation the freedom to look at new ideas and concepts wherever they may be found and to explore some of them through the proof-of-concept stage if they contained promise in the research stages. The research work through the proof-of-concept stage supported by NSF would be funded mainly from its own appropriation. If it becomes desirable to have funds transferred to the Foundation from other agencies, the Foundation has authority to accept and use such funds from other agencies for such research.

To summarize, the National Science Foundation fully endorses the enactment of S. 2744 and the establishment of an Energy Research and Development Administration to achieve a more effective management of the energy-R&D functions of the Federal Government. We believe that NSF's role of research in selected energy areas is fully compatible with the ERDA concept and will serve to support and strengthen ERDA when it is created. The mandate of the Foundation gives it the flexibility to initiate and support energy research, and its continuing role therein would be in harmony with the broader purposes of S. 2744.

On behalf of Dr. Stever, I thank you for the chance to express the Foundation's views on S. 2744 to you and to the Subcommittee on Reorganization, Research and International Organizations of the Committee on Government Operations.

The Office of Management and Budget has advised us that there is no objection to the submission of this report from the viewpoint of the Administration's program.

Sincerely yours,

RAYMOND L. BISPLINGHOFF,
Acting Director.

Enclosure.

NSF/RANN SOLAR ENERGY RESEARCH GRANTS AND CONTRACTS IN FISCAL YEAR 1973

Institution and program manager	Title and grant No.	Amount	Duration (mo.)	Effective date
Heating and cooling of buildings:				
American Society of Heating, Refrigeration, and Air Conditioning, C. MacPhee.	Preparation and publication of an ASHRAE guide chapter on the application of solar energy for heating and cooling of buildings (GI-39247).	$5,000	12	July 1, 1973
University of Florida, E. Farber	Formulation of a data base for the analysis, evaluation, and selection of a low-temperature solar powered air-conditioning system (GI-39323).	49,400	9	Do.
University of Maryland, R. Allen	Optimization studies of solar absorption air-conditioning systems (GI-39117).	129,300	18	Aug. 15, 1973
University of Wisconsin, J. Duffie	Computer modeling and simulation of solar heating and cooling systems (GI-34028-1).	65,300	12	Oct. 1, 1973
Solar thermal conversion:				
Aerospace Corp., A. Greenberg	Solar thermal conversion mission analysis (C-797).	125,885	6	Apr. 16, 1973
Do	System analysis of photothermal conversion systems (C-716-1).	12,118		May 23, 1973
University of Arizona, B. Seraphin	Chemical vapor deposition research for fabrication of solar energy conversion (GI-36731X).	171,200	12	Jan. 1, 1973
Colorado State University (Westinghouse), G. Lof.	Analysis of solar-thermal electric power systems (GI-37815).	491,800	18	Apr. 1, 1973
University of Houston (McDonnell-Douglas Astronautics Co.) L. Vant-Hull.	Feasibility study of a solar thermal power system based upon optical transmission (GI-39456).	130,900	12	June 15, 1973
University of Minnesota (Honeywell) R. Jordan.	Research applied to solar-thermal power systems (GI-34871X1).	494,700	12	July 1, 1973
Photovoltaic conversion:				
American Cyanamid Co. (University of Penn and University of Delaware), G. Haacke.	Research on cadmium stannate selective optical films for solar energy applications (GI-39539).	151,500	18	Do.
Boston College, P. Fang	Low-cost polycrystalline silicon photovoltaic cells for large solar power systems (GI-34975-1).	67,100	9	June 15, 1973
Boston University (Exxon Research), N. Lichtin.	Photochemical conversion of solar energy (GI-38103).	115,000	12	June 1, 1973
Brown University, J. Loferski	Investigation of thin film solar cells based upon Cu_2S and ternary compounds (GI-38102X).	76,900	12	July 1, 1973
University of California/Berkeley, G. Somorjai.	Studies of surface structure and electronic properties of polycrystalline photovoltaic materials and devices (AG-472).	186,700	18	July 1, 1973
Harvard University (Tyco Laboratories), B. Chalmers.	Low-cost continuous fabrication of silicon solar cells (GI-37067X).	150,000	12	Mar. 1, 1973
Southern Methodist University (Texas Instrument Corp.), T. Chu.	Development of low-cost thin film polycrystalline silicon solar cells for terrestrial applications (GI-38981).	149,400	18	June 1, 1973
Stanford University, R. Bube	Applied research on II-VI compound materials for heterojunction solar cells (GI-38445X).	48,300	12	July 1, 1973
Bioconversion:				
University of California/Berkeley, W. Oswald.	Solar energy fixation and conversion with algal-bacterial systems to produce methane (GI-39216).	51,800	18	May 1, 1973
Dynatech Research and Development Co. (University of Massachusetts and Massachusetts Institute of Technology), D. Wise.	Research on a program for economic fuel gas production from solid waste (C-827).	427,000	13	June 28, 1973
University of Illinois, J. Pfeffer	Biological conversion of organic refuse to methane (GI-39191).	83,900	12	June 1, 1973
University of Massachusetts, W. Short.	Bioconversion energy research conference (GI-39615).	17,800	5	May 15, 1973
Stanford Research Institute, J. Henry.	Effective utilization of solar energy to produce clean fuel (GI-38723).	49,000	9	May 1, 1973
University of Tennessee, A. Hollaender.	Workshop on energy conversion sources (GI-35970).	18,500	6	Sept. 15, 1972
Wind conversion:				
Montana State University, R. Powe.	Technical feasibility study of a wind energy conversion system based on the tracked-vehicle airfoil concept (GI-39415).	49,900	12	Sept. 1, 1973
NASA/Lewis Research Center, J. Savino.	Wind energy conversion workshop (AG-465).	11,700	6	June 1, 1973
Oklahoma State University, W. Hughes.	Development of an electrical generator and electronics cell for a wind energy conversion system (GI-39457).	141,600	18	July 1, 1973

NSF/RANN SOLAR ENERGY RESEARCH GRANTS AND CONTRACTS IN FISCAL YEAR 1973—Continued

Institution and program manager	Title and grant No.	Amount	Duration (mo.)	Effective date
Ocean thermal conversion:				
Carnegie-Mellon University, A. Lavi.	Conference on power generation for ocean temperature differences (GI-39115).	14,000	12	May 15, 1973
Carnegie-Mellon University, C. Zener.	Solar power ocean-based plants (GI-39114).	190,000	18	June 1, 1973
University of Massachusetts (J. H. Anderson, Inc. and United Aircraft Research Laboratories), W. Heronemous.	Ocean-sited powerplants (GI-34979-1)	25,200	18	Feb. 15, 1973
Program analysis:				
Audio Productions, P. Mooney	Motion picture services (C-664)	7,000	3	Nov. 30, 1972
International Solar Energy Society (ISES), W. Cherry.	Printing of the 1973 international solar energy congress abstracts (GI-39240).	10,000	6	June 1, 1973
University of Maryland, R. Allen	Solar energy panel (GI-32488-2)	24,600	6	Nov. 1, 1972
University of Maryland, F. Morse	Personnel mobility assignment	34,900	11	Sept. 1, 1973
University of Massachusetts, R. Ward.	do	21,000	9	Oct. 1, 1973
Mitre Corp., R. Greeley	System study of the NSF solar energy research program (C-831).	152,334	4	July 1, 1973
University of Pennsylvania, M. Wolf.	Solor energy research conference (GI-37124).	11,000	6	Feb. 1, 1973

NSF/RANN Solar Energy Grant: GI-39247
Granted: 6/8/73
Institution: ASHRAE
Principal Investigator: Carl W. MacPhee
Project Title: Preparation and Publication of an ASHRAE Guide Chapter on the Application of Solar Energy for Heating and Cooling of Buildings
Amount: $5,000
Eff. Date: 7/1/73
Duration: 12 mos.

The substantial research program on the application of Solar Energy for Heating and Cooling of Buildings supported by the National Science Foundation, RANN Directorate has begun to generate new data not generally available to practicing engineers and mechanical construction contractors. This project will support the collection, analysis and condensation of this new material into a form most useful to practicing mechanical engineers and builders. The material produced will be published as a chapter in the ASHRAE Guide, widely regarded as the "bible" of the air conditioning, heating and mechanical ventilation industry. Through this process, the availability of new research information will be expedited to potential users outside the research and development community.

NSF/RANN Solar Energy Grant: GI-39323
Granted: 6/11/73
Institution: University of Florida
Principal Investigator: E. A. Farber
Project Title: Formulation of a Data Base for the Analysis, Evaluation and Selection of a Low Temperature Solar Powered Air-Conditioning System
Amount: $49,400
Eff. Date: 7/1/73
Duration: 9 mos.

The development of an economical and efficient means of cooling buildings with solar energy is considered an important requirement for the implementation of solar energy as an alternative to fossil energy sources for producing thermal comfort in buildings. This project will provide an engineering evaluation of water cooled and air cooled refrigerant systems and related machinery upon which recommendations can be made for the development of an operational unit. If found feasible, such a unit will be considered for fabrication and installation in a solar heated house now in operation at the University of Florida. The proposed work covers only the preliminary engineering development phase.

NSF/RANN Solar Energy Grant: GI–39117
Granted: 5/21/73
Institution: University of Maryland
Principal Investigator: Redfield W. Allen
Project Title: Optimization Studies of Solar Absorption Air Conditioning Systems
Amount: $129,300
Eff. Date: 8/15/73
Duration: 18 mos.

The objective of this project is the evaluation of the effects of system options and actual process factors on the performance and optimization of solar absorption air conditioning systems. Specific goals include (1) the development of parametric performance factors for ideal and actual system operation at various thermodynamic conditions, (2) evaluation of the thermal heliotrope for use with sun-tracking collectors, (3) the thermodynamic and economic optimization of the collector and absorption refrigeration systems.

In a recent study, the NSF/NASA Solar Energy Panel concluded that, with at substantial development program, by the year 2000 solar energy could economically provide up to 10% of the total building heating and cooling energy requirements. This represents a major impact on the building industry, with an annual fossil fuel savings of approximately $2.1 billion, based on a fuel cost of $\$1.00/10^6$ btu. While the energy requirements for air conditioning are a small fraction of the total annual building heating and cooling energy demand, the rapidly growing air conditioning power demands periodically tax the peak load capacity of regional power networks. This situation gives added emphasis to the need to develop solar powered air conditioning. Once solar air conditioning becomes a marketable product it will be possible to combine it with solar heating, with associated savings in initial cost. This project to conduct optimization studies of solar powered air conditioning systems, should define limitations of present technology and point to ways of lowering cost and improving performance.

NSF/RANN Solar Energy Grant: GI–34028–1
Granted: 6/11/73
Institution: University of Wisconsin
Principal Investigator(s): Beckman, W. A.—Duffie, J. A.
Project Title: Computer Modeling and Simulation of Solar Heating and Cooling Systems
Amount: $65,300
Eff. Date: 6/11/73
Duration: 12 Mos.

This grant provides for the last 12 months of a 27 month project to model heating and cooling systems for buildings. The general objectives are to develop a versatile simulation tool to evaluate from engineering and economic points of view various processes for utilizing solar energy for building energy needs, and to use the simulations to evaluate solar heating and cooling processes in various United States locations. The simulations will be useful in selecting processes for further development and aid in the design of specific applications of solar energy to buildings. The general approach using the concept of a versatile "building block" program, in which various combinations of a process' components can be evaluated, has proved to be a valid one. The approach has been a step by step development of component models and of matter programs for using component models in system analyses. The plan includes the following specific tasks: 1) Complete simulations of water heating/storage/LiBr-H O cooler system, and compare results with those of Tybout and Lof for selected stations. 2) Comparisons check of the model for heating systems alone with stations evaluated by Tybout and Lof. 3) Run water heating/collector/storage/absorption cooler models for several locations. 4) Run heating/hot water systems for Madison, WI. 5) Program and evaluate air heating systems with rock bed storage, with or without absorption cooling or open-cycle humidification-dehumidification cooling. 6) Evaluate other concepts of heating and cooling systems for buildings. 7) Explore some of the major design parameters, evaluate the processes from thermal and economic standpoints, and identify critical design considerations.

NSF/RANN Solar Energy Grant: C–797
Granted: 4/16/73
Institution: Aerospace Corporation
Principal Investigator: A. B. Greenberg
Project Title: Solar Thermal Conversion Mission Analysis
Amount: $125,885
Eff. Date: 4/16/73
Duration: 6 mos.

The objectives of this study are to (1) develop a methodology for assessing the potential role of solar thermal conversion systems in satisfying a portion of the nation's energy needs, (2) develop a methodology for comparative analysis of competing solar thermal conversion systems, and (3) apply this methodology to assess the potential of various types of solar thermal conversion systems in Southern California.

The methodology will include (a) the ability to incorporate various projected energy demands for different regions of the country for the period 1990–2020, (b) a selected approach to standardize solar insolation flux calculations, (c) the definition of mission requirements appropriate for central station power plants, municipal power plants, community power systems, and/or individual load centers, (d) the identification of key parameters and definition of system/subsystem requirements, (e) the identification and definition of system/subsystem constraints and competing characteristics including economic, environmental, social, and institutional factors, (f) synthesis of alternative systems, and (g) an assessment technique to estimate market capture potential. The method will be tested with specific data for Southern California in order to assess the completeness/validity of the methodology.

NSF/RANN Solar Energy Grant: C–716–1
Granted: 5/23/73
Institution: Aerospace Corporation
Principal Investigator: A. B. Greenberg
Project Title: Systems Analysis of Photothermal Conversion Systems
Amount: $12,118
Eff. Date: 5/23/73
Duration:

This is a continuation of Grant C–716.

The assessment of a system concept will include technical and economic feasibility studies of each principal component, identification of key technical and economic problem areas, and evaluation of the credibility and capability of the overall concept to meet system objectives. An important aspect of an assessment will be the development of realistic performance characteristics and cost estimates for each system concept. Results from assessments of components and concepts will be used in comparative systems analysis to evaluate advantages and disadvantages of various components and concepts. Estimates will be made of research and time schedules to bring each concept to a relatively developed level where economic feasibility can be determined. Program planning documents and schedules for demonstration plants and prototype plants will be prepared. Some attention will be given to cost comparisons of photothermal electrical generating plants with nuclear and fossil fuel plants in the 1990's.

NSF/RANN Solar Energy Grant: GI–36731
Granted: 9/20/72
Institution: University of Arizona
Principal Investigator: Bernhard O. Seraphin
Project Title: Chemical Vapor Deposition Research for Fabrication of Solar Energy Converters
Amount: $171,200
Eff. Date: 9/15/72
Duration: 12 mos.

This project will support research on a new approach to a selective solar energy converter that can be used to transform solar radiation into high temperature heat. This heat can be transferred and applied to a steam turbine-generator unit to produce electricity. The selective solar energy converter is basically a two-layered construction in which the top layer is a semiconductor material, such as silicon, having high absorption for solar radiation and high transparency for black body radiation from the heated unit. The bottom layer is a metal film having high reflectance.

A second significant feature of this project is the use of chemical vapor deposition (CVD) techniques for applying semiconductor materials for optical structures. The objective of the project is to adapt the CVD process to the fabrication of multilayered semiconductor coatings, to demonstrate the fabrication of semiconductor absorber-type optical coatings, and to measure the physical characteristics and the optical performance of these coatings as a function of temperature up to 500 C.

A previous NSF grant GI–30022 has supported initial work in evaluating various coating methods for fabricating multilayer stacks utilizing semiconductor materials. Results of this work have provided new understandings of system variables in the pyrolysis of silane on silver surfaces and have demonstrated the practicality of forming more complex layered structures using CVD techniques.

NSF/RANN Solar Energy Grant: GI–37815
Granted: 4/6/73
Institution: Colorado State University
Principal Investigator: G. O. G. Lof
Project Title: Analysis of Solar-Thermal Electric Power System
Amount: $491, 800
Eff. Date: 4/6/73
Duration: 18 mos.

The objective of this research project is to develop very general and widely applicable analytical relationships for describing the detailed functioning of solar thermal electric power systems. Using mathematical modeling techniques, these analytical relationships would be used to optimize the design of the various components and subsystems and the design of entire systems for generating electricity from solar energy using heat engines and relatively conventional turboelectric generative equipment. Computerized mathematical models will be developed and used to produce information for component and systems engineering and optimization and to correlate power output and costs with system design parameters and insulation data. The plan is to develop component and subsystem models in forms suitable for use in larger models of entire systems in order to optimize a solar thermal power system to produce power at the lowest cost.

Under this project, all known methods for solar conversion to heat energy and for heat energy transfer, storage, and conversion will be examined so that future research and development funds can be applied most effectively and so that some potentially attractive systems will not be overlooked. The research project will provide information required for the selection of the best methods and systems for practical generation of electricity from solar energy by a thermal process.

The project will include data collection and organization, conceptual development of components and subsystems, preliminary component engineering, preliminary systems engineering, cost analysis, and environmental impact.

NSF/RANN Solar Energy Grant: GI–38456
Granted: 6/26/73
Institution: University of Houston
Principal Investigator: Lorin L. Vant-Hull
Project Title: Feasibility Study of a Solar Thermal Power System Based Upon Optical Transmission
Amount: $130,900
Eff. Date: 9/1/73
Duration: 12 Mos.

The objective of this project is to perform a preliminary technical and economic feasibility study of a solar thermal electric power system based upon optical transmission or collected solar energy to a central location. The study includes system definition, modeling, and preliminary component design. In the concept, solar radiation is reflected from a relatively large number (field) of steered mirrors to a common target receiver located on a central tower. The highly concentrated solar radiation impinging on the receiver surface is largely absorbed and converted to high temperature heat energy that is used to drive a heat engine to produce mechanical or electrical power. This approach to solar energy collection utilizes the transmission path of reflected light to bring relatively large quantities of energy to a central location-thus avoiding the need for relatively extensive heat transfer networks from field arrarys of collectors to a central collection point. Of course, another set of problems are encountered in this approach to developing an efficient, economical collection system for solar energy. This project is a combined effort by staff of the University of Houston and the McDonnell Douglas Astronautics Company. The approach includes completion

of Tasks on (1) the solar flux concentration system, including system geometric analysis of the optical characteristics, guidance and control system studies, and reflector designs; (2) the receiver and energy transfer system including conceptual designs of the tower; and, (3) system definition and evaluation with particular attention to economic analysis of the collection, energy transfer, and energy conversion systems.

NSF/RANN Solar Energy Grant: GI–34871X1
Granted: 6/29/73
Institution: University of Minnesota
Principal Investigator: R.C. Jordan
Project Title: Research Applied to Solar-Thermal Power Systems
Amount: $494,700
Eff. Date: 7/7/73
Duration: 12 mos.

This project is the second-year continuation of a two-year project initiated in FY 1972. It is a collaborative project between the University of Minnesota and Honeywell Corporation to conduct research on solar thermal conversion systems to produce electricity or high temperature process heat. Substantial progress has been made in analyzing the optical characteristics of solar ray collector-absorber systems using three-diminsional computer modelling; testing and evaluating mirror surface coatings; calculating absorber coating characteristics and testing coating lifetimes under accelerated life conditions; analyzing and testing of gravity assisted heat pipes; analyzing heat transfer and storage concepts; and analyzing subsystem and system characteristics.

The continuing research will extend the previous work and undertake new tasks based upon the progress to date. These tasks in the continuing project include work on (1) solar reflector surface life, (2) solar absorber coating life, (3) design, fabrication, and test of a 12 meter prototype heat pipe, (4) experiments with heat transfer test facilities, (5) experiments with a central heat storage test facility, (6) analysis of heat transfer in heat storage units, (7) selection of a reference system and recommendations for additional research, (8) design, fabrication, and test of a solar thermal collection system using a three-eighths scaled model, (9) analysis of insulation of transfer loops, (10) heat exchanger interfaces with heat pipes, transfer storage, and boilers, and (11) system cost estimates.

NSF/RANN Solar Energy Grant: GI-39415
Granted: 6/20/73
Institution: American Cyanamid Company
Principal Investigator: G. Haacke
Project Title: Research on Cadmium Stannate Selective Optical Films for Solar Energy Applications
Amount: $151,500
Eff. Date: 7/1/73
Duration: 18 mos.

The objective of this research project is to develop a transparent, electrically conductive material, cadmium stannate (Cd_2SnO_4), for incorporation into CdS solar cells and solar heat collectors. The research will seek to develop technology for the preparation of crystalline Cd_2SnO_4 films and optimize the electrical and optical properties of these films for energy conversion applications. Optical data on Cd_2SnO_4 films will be evaluated for use as coatings for flat plate collector covers. When the desired optical properties are achieved, flat plate collectors will be assembled and tested to determine heat collection efficiency. Cd_2SnO_4 films on transparent substrates will be used for the fabrication of thin film CdS solar cells and the photovoltaic properties of these cells will be evaluated.

A feasibility study of low-cost methods for the production of large area Cd_2SnO_4 coatings will be conducted.

NSF/RANN Solar Energy Grant: GI-34975-1
Granted: 4/20/73
Institution: Boston College
Principal Investigator: Paul H. Fang
Project Title: Low-Cost Polycrystalline Silicone Photovoltaic Cells for Large Solar Power Systems
Amount: $67,100
Eff. Date: 6/15/73
Duration: 9 mos.

During the first year of this study, three different growth techniques (evaporation, chemical vapor deposition, and sputtering) were successfully used to form polycrystalline silicone, approximately 10μ thick, on several different substrates.

The crystallinity and crystal grain size of the silicone film was examined by x-ray diffraction and optical investigation. Certain silicone films, formed by evaporation onto foil or quartz substrates, exhibited a polycrystal structure with small and uniform grains of about 10μ size. Preliminary electrical conductivity measurements indicate acceptable values in the 20–100Ω-cm. Additional characterization of the polycrystalline films will be made and junction information techniques will be developed.

NSF/RANN Solar Energy Grant: GI–38103
Granted: 4/23/73
Institution: Boston University
Principal Investigator: Norman N. Lichtin
Project Title: Photochemical Conversion of Solar Energy
Amount: $115,000
Eff. Date: 6/1/73
Duration: 12 mos.

This grant is for the identification and characterization of inorganic photoredox systems which can be used in solar powered photogalvanic cells or for the photo formation of fuels. Fundamental research concerned with photo chemical reactions of coordinating complexes of transition metals will be performed in the chemistry department of Boston University. Applied research concerned with the investigation of devices which employ the photo chemical processes studied at Boston University will be performed at Corporation Research Energy Conversion Unit of Exxon Research and Engineering Co. The overall goal is for the construction and demonstration of a photogalvanic cell which has 5% engineering efficiency, i.e., converts at least 5% of the energy of the solar flux at ground level into electrical power. There is anticipated an achievement of 25% guantum efficiency of photo generation of useful fuel by photoredox reactions of homogeneous inorganic aqueous solutions.

NSF/RANN Solar Energy Grant: GI–38102
Granted: 9/20/72
Institution: Brown University
Principal Investigator: Joseph J. Loferski
Project Title: Investigation of Thin Film Solar Cells Based on Cu_2S and Ternary Compounds
Amount: $76,900
Eff. Date: 7/1/73
Duration: 12 mos.

The objective of this project is the investigation of thin film solar cells based on Cu_2S and ternary compounds of the type $CuInS_2$ and $CuInSe_2$ for large scale, hence low-cost, terrestrial solar energy utilization. Specific goals include the fabrication and testing of (1) metal-semiconductor photovoltaic cells consisting of Cu_2S or Cu, (2) homojunction cells involving $CuInS_2$ on Cu, 3) heterojunction cells involving $CuInS_2$ on Cu, 3) heterojunction cells of $CuInS_2$, 4) heterojunction cells consisting of P-type $CuAlS_2$, 5) heterojunction cells of Cu_2S on single crystal Si, and, 6) homojunction cells involving $CuInSe_2$ and $CuInSe_xS_1$-x.

The conversion of solar energy directly to electric power using silicon solar cells (photovoltaic conversion) is a proven technology for use in space where power is very valuable. This same general technology could be used to generate substantial quantities of terrestrial power from solar radiation if the system costs can be reduced below space costs by a factor of 100 to 1000, principally the costs of producing reliable photovoltaic conversion devices. This project is directed towards the problem of developing new photovoltaic materials having the promise for low-cost, long-lived solar arrays for use in terrestrial applications, providing power with minimum environmental effects and with reduced dependence on nonrenewable fuel resources.

NSF/RANN Solar Energy Grant: AG–472
Granted: 6/26/73
Institution: University of California
Principal Investigator: Gabor A. Somorjai
Project Title: Studies of Surface Structure & Electronic Properties of Polycrystalline Photovoltaic Materials and Devices
Amount: $186,700
Eff. Date: 7/1/73
Duration: 18 Mos.

The objective of this project is to establish the relationship between the electronic properties and the surface structure and indepth composition of thin

film polycrystalline photovoltaic devices. The motivation is to develop devices having high conversion efficiencies and low-cost potential. Specific goals of this project include (1) to study the morphology of thin polycrystalline films of various materials and to correlate this with electronic properties, (2) to study the correlation between surface structure, junction region, composition changes with thickness and electronic properties of currently available single-crystal silicon solar cells, of polycrystalline silicon solar cells, and of polycrystalline CdS/Cu-S solar cells, and (3) to evaluate how changes in film deposition parameters influences device performance through the effect on the surface structure.

The conversion of solar energy directly to electric power using single crystal silicon solar cells is a proven technology for use in space. This same general technology could be used to generate substantial quantities of terrestrial power from solar radiation if the photovoltaic system costs can be reduced below space costs by a factor of 100 to 1000. This project is concerned with research to examine advanced methods for producing thin films of polycrystalline silicon, which could then be used to develop an automated continuous process for producing these cells and to reduce cell costs per wall substantially below those of present production methods.

NSF/RANN Solar Energy Grant: GI–37067X
Granted: 4/4/73
Institution: Harvard University
Principal Investigator(s): Bruce Chalmers, A. I. Mlavsky
Project Title: Low-Cost Continuous Fabrication of Silicon Solar Cells
Amount: $150,000
Eff. Date: 3/1/73
Duration: 12 mos.

The goal of this project is the development of techniques for low-cost continuous production of silicon crystal ribbon for continuous manufacture into low-cost silicon solar cells. A technique of crystal growth has been developed by the university and industrial collaborators in this proposal and has been previously applied to the production of continuous sapphire single crystal shapes including large single crystal ribbons. Their technique of *E*dge-defined, *F*ilm-fed, *G*rowth (EFG) of single crystals is a process by which single crystals may be grown having a shape controlled by the outside dimensions of a die with the crystal growth taking place from a very thin film of liquid fed by capillary action from a crucible below. This project proposes research to develop the basic understanding and the engineering processes necessary for the application of the EFG-process to the growth of silicon single crystal ribbons that can be used in continuous production of silicon solar cells.

The conversion of solar energy directly to electric power using silicon solar cells (photovoltaic conversion) is a proven technology for use in space where power is very valuable. This same general technology could be used to generate substantial quantities of terrestrial power from polar radiation if the system costs can be reduced below space costs by a factor of 100 to 1000, principally the costs of producing reliable photovoltaic conversion devices. This project seeks to develop a process for producing low-cost, suitable silicon solar cells for use in practical, large-scale terrestrial power systems that could produce power with minimum environmental effects and with reduced dependence on nonrenewable fuel resources.

NSF/RANN Solar Energy Grant: GI–38981
Granted: 5/4/73
Institution: SMU
Principal Investigator: Ting L. Chu
Project Title: Development of Low-Cost Thin Film Polycrystalline Silicon Solar Cells for Terrestrial Applications
Amount: $149,400
Eff. Date: 6/1/73
Duration: 18 Mos.

The objective of this project is the development of low-cost thin film polycrystalline silicon solar cells suitable for large-scale terrestrial utilization. Specific goals include (1) the deposition and characterization of polycrystalline silicon films of adequate quality, (2) the preparation and characterization of suitable junction, of the p n type and/or the Schottky barrier type, and (3) the fabrication and evaluation of thin film solar cells having efficiencies and cost projections warranting further research and development support.

The conversion of solar energy directly to electric power using single crystal silicon solar cells is a proven technology for use in space. This same general technology could be used to generate substantial quantities of terrestrial power from

solar radiation if the photovoltaic system costs can be reduced below space costs by a factor of 100 to 1000. This project is concerned with research to examine advanced methods for producing thin films of polycrystalline silicon, which could then be used to develop an automated continuous process for producing these cells and to reduce cell costs per wall substantially below those of present production methods.

NSF/RANN Solar Energy Grant: GI–38445X
Granted: 5/4/73
Institution: Stanford University
Principal Investigator: Richard H. Bube
Project Title: Applied Research on II–VI Compound Materials for Heterojunction Solar Cells
Amount: $48,300
Eff. Date: 7/1/73
Duration: 12 mos.

The objective of this project is the investigation of heterojunction solar cells based on several II–VI systems suitable for large-scale terrestrial utilization. Specific goals include the preparation and characterization of the CdTe-Cds, ZnTe-ZnSe, CdTe-ZnSe and ZnTe-CdS systems. The Bi_xS_yCdS system will also be studied.

The terrestrial conversion of solar energy directly to electricity using thin film Cu_2S-CdS offers many benefits over the silicon solar cells developed for use in space. The difficulties encountered with the Cu_2S-CdS cell, while presently under active investigation, suggests that new photovoltaic materials, keeping the positive advantages of the Cu_2S-CdS system, while avoiding the stability and degradation problems, are needed. This project is directed towards the problem of preparing and testing several II–VI compound photovoltaic materials having the promise of low-cost, long-lived solar arrays for terrestrial applications. •

NSF/RANN Solar Energy Grant: BI–39216
Granted: 5/14/73
Institution: University of California
Principal Investigator: William J. Oswald
Project Title: Solar Energy Fixation & Conversion With Algal-Bacterial Systems to Produce Methane
Amount: $51,800
Eff. Date: 5/1/73
Duration: 18 mos.

A study which involves optimization of a solar energy conversion and waste utilization system, whereby the visible light energy component of solar energy will be fixed through photosynthesis as the chemical energy of algae cellular material growing on wastes. Through the process of anaerobic digestion, variable fractions of the chemical energy of the algae cellular material will, in turn, be converted to chemical energy in the form of methane. The nutrients in wastes and recycled materials will be rendered soluble and available for additional algae growth by successive aerobic and anaerobic bacterial action.

The national significance of the prolect rests in the fact that, to the extent it is economical, the process will aid in meeting the nation's critical energy needs through multipurpose use of land and facilities to produce: (1) a renewable clean energy resource either in the form of combustible gas or as electricity, (2) an environmentally and economically sound method for treating and recycling the increasing amounts of concentrated organic wastes, and (3) a potentially inexpensive source of protein rich animal feed.

During this phase the investigators will (a) undertake a detailed economic study and econopic feasibility report on the process of algae solar energy conversion; and (b) explore the comparative methane fermentation rates of a number of species of algae.

NSF/RANN Solar Energy Grant: C–827
Granted: 6/28/73
Institution: Dynatech Research and Development Co.
Principal Investigator: Donald L. Wise
Project Title: Research on a Program for Economic Fuel Gas Production from Solid Waste
Amount: $427,000
Eff. Date: 6/28/73
Duration: 13 mos.

The objective of the project is the development of a process for the economic production of transmission line fuel gas from the large organic fraction of munici-

pal solid waste. Laboratory experiments on the anaerobic digestion of solid waste and the feasibility of this new recovery/gas production process has been demonstrated. Continuing research and development is now required using a pilot plant designed to carry out experiments on 1 ton/day of municipal solid waste. The proposed program is one of engineering development integrated with an effective testing and evaluation program. Emphasis has been placed on the formation of an interdisciplinary team, and it is intended that guidance of the project plant will be through quarterly meetings of this team. The pilot plant, operation administration, and management will be carried out by Dynatech R/D Co., a firm experienced in the production of fuel gas from solid waste. Experiments will also be carried out by faculty, and students at the University of Massachusetts, MIT, and Northeastern University. Consolidated Natural Gas Service Co., Inc., a distributor of fuel gas produced by the proposed process will cost share this project by contributing $125,000. The Black Clawson Co., equipment vendors, will supply at no cost, equipment suited for preparation of the solid waste for conversion to fuel gas. Local, municipal, county, state and Federal Government representatives complete the project team. It is intended that individuals representing the technical disciplines and the industrial and municipal groups on the project team will participate in the project early in the program as well as continuously through the two years duration proposed for the program.

NSF/RANN Solar Energy Grant: GI–39191
Granted: 6/1/73
Institution: University of Illinois
Principal Investigator: John T. Pfeffer
Project Title: Biological Conversion of Organic Refuse to Methane
Amount: $83,900
Eff. Date: 6/1/73
Duration: 12 mos.

The objectives of this project are to investigate several of the problem areas of bio-conversion. The bio-conversion process has been applied as a laboratory scale to the conversion of refuse and wastewater sludge to methane gas on a laboratory scale. The result of the laboratory studies have been encouraging. Studies will be carried out on the effluent wastes of the process and work will be carried on with Dynatech and others to develop the necessary guidelines for a large-scale system. A mathematical simulation of the system will be developed for predicting the most practical combination of process variables for producing methane at the lowest cost. The analysis will demonstrate the economic practicality of the system.

NSF/RANN Solar Energy Grant: GI–39215
Granted: 5/16/73
Institution: University of Massachusetts
Principal Investigator: W. Leigh Short
Project Title: Bioconversion Energy Research Conference
Amount: $17,800
Eff. Date: 5/15/73
Duration: 05 mos.

A conference on the subject of Biological Conversion of Waste Materials to Methane will be convened at the University of Massachusetts on May 31 and June 1, 1973. Those to be invited include researchers active in the field of bioconversion as well as others concerned with various aspects of this process. Participants would include representatives from appropriate federal, state and local governmental agencies, industries (e.g. meat packing, utilities, waste handling) and universities. The objectives of the conference are: (1) To exchange information between engineers and scientists on research accomplishments and problems related to bioconversion studies, (2) to contribute to the long range planning of the funding agencies and research workers in the field, (3) to provide improved communications between the research community and the user groups, (4) to identify the processes and technology important to the production of methane from waste and feed lot materials, and (5) to identify the important economic factors associated with bio-conversion processes. The report of the conference will be prepared in the Institute and disseminated to all participants as well as other interested agencies and groups. Two hundred copies will also be supplied to the National Science Foundation. Each speaker will prepare a written summary of his presentation to be included in the report. These summaries will be supplemented with materials from the discussion sessions following each presentation. The report will be ready for distribution approximately six weeks after the conference.

NSF/RANN Solar Energy Grant: GI–38723
Granted: 4/20/73
Institution: Stanford Research Institute
Principal Investigator: John P. Henry
Project Title: Effective Utilization of Solar Energy to Produce Clean Fuel
Amount: $49,000
Eff. Date: 5/1/73
Duration: 9 mos.

Principal Investigator: John P. Henry, Jr. The goal of this project is to examine and evaluate the technical and economic feasibility of growing large quantities of organic materials (biomass) to be harvested and converted to power directly through combustion processes or to clean fuels, e.g., methane, through bioconversion or other processes. In this concept, large fuel farms would be used to convert solar energy to biomass through photosynthesis processes in land or aquatic plants.

The objective of the analysis are to determine the types of vegetation best suited for producing and harvesting massive quantities of plant tissue; to assess the type and availability of lands or waters for growing the desired crops including isolation, climate, water availability, soil characteristics, current land use and value; to examine the logistics of growing, harvesting, and transporting desirable crops; to evaluate plants for yield characteristics, growth requirements, heat of combustion, disease resistance, etc.; to compare firing the crops directly to produce electric power with conversion of them to clean fuel gas (high or low-Btu gas) either at the farm site or at a remote site; to analyze power costs from cultivated fuels; to analyze net energy production in the projected system; and to assess the overall project feasibility—both technically and economically—including a sensitivity analysis of the many contributing cost factors and the outlook or improving the economics in the future. Recommendations for research in key areas of technical and economic uncertainties will be developed.

NSF/RANN Solar Energy Grant: GI–35970
Granted: 9/20/72
Institution: University of Tennessee
Principal Investigator: Alexander Hollaender
Project Title: Workshop on Energy Conversion Sources
Amount: $18,500
Eff. Date: 9/15/72
Duration: 6 mos.

This project proposes to conduct a workshop for the purpose of summarizing our present understanding of biological energy conversion processes and identifying problem areas that must be resolved to develop practical energy conversion systems utilizing biological processes. Through encouraging cooperation in exploring the possibilities for exploitation of new sources of energy, e.g., conversion of sunlight by biological materials and transformations of organic and mineral materials by biological organisms, more rapid progress and more pointed research projects can result. This workshop will meet for about three days and will bring together about 45 invited engineers, biologists, geologists, microbiologists, biochemists, etc. to discuss problems of mutual interest in these research areas. Through public notices of this workshop, other engineers and scientists will be able to participate if they are interested in attending at their own expense. The exchange of ideas and information is expected to stimulate new interdisciplinary approaches that might not otherwise have developed as rapidly.

NSF/RANN Solar Energy Grant: GI–39415
Granted: 6/21/73
Institution: Montana State University
Principal Investigator: Ralph E. Powe
Project Title: Technical Feasibility Study of a Wind Conversion System Based on the Tracked Vehicle-Airfoil Concept
Amount: $49,900
Eff. Date: 9/1/73
Duration: 12 Mos.

The objective of this proposal is to evaluate the technical feasibility of a wind energy conversion system based on the tracked vehicle-airfoil concept. Specific goals include (1) to establish performance specifications for the major system components and to identify interface requirements, (2) to formulate sets of alternative system designs to meet above conditions, (3) to perform engineering

analysis of these systems, to identify major strengths and weaknesses and to select most promising design, (4) to initiate a detailed systems design, including economic considerations, to establish technical feasibility.

Solar energy sustains the winds. It is calculated that the power potential in the winds over the continental U.S., the Aleutian arc and the Eastern seaboard is about 10^{11} kilowatts electric. Winds are remarkably repeatable and predictablee The momentum in moving air can be extracted by momentum-interchangl machines located in suitable places such as plains, valleys, and along the continental coastal shelves. A desirable windpower system would incorporate a storage and a peaking capability, thereby being able to span between the variable wind and the patterned electricity consumer demand. This project is concerned with assessing the technical feasibility of a novel momentum-interchange device which involves vertical airfoils mounted on carriages which move along on a horizontal closed track system.

NSF/RANN Solar Energy Grant: AG–465
Granted: 5/31/73
Institution: NASA/Lewis Res, Ctr.
Principal Investigator: Joseph M. Savino
Project Title: Wind Energy Conversion Workshop
Amount: $11,700
Eff. Date: 6/1/73
Duration: 06 Mos.

A wind energy conversion workshop will be held in Washington, D.C., June 11, 12, and 13, 1973. The purpose of this workshop is to provide a forum for discussions of governmental, research and development, and industrial aspects of wind energy conversion systems. These discussions will provide for:

Information exchange on research project accomplishments
An assessment of the state of the art
The priorties for future efforts

The workshop will bring together people who have been or are presently active in this field, as well as representatives from the power equipment industry, appropriate aircraft industries, government agencies—such as the FPC, DOI, NOAA and the potential users—such as utilities, industry, etc.

The program will include short presentations by representatives from each research project, and will provide discussion periods to address such general questions as coordination, continuing information exchange, communications with the user community, contributions to program planning and operation, and cooperation in other solar energy applications. These discussions will benefit the entire program.

NSF/RANN Solar Energy Grant: GI–39457
Granted: 6/20/73
Institution: Oklahoma State University
Principal Investigator: William L. Hughes
Project Title: Development of an Electrical Generator and Electrolysis Cell for a Wind Energy Conversion System
Amount: $141,600
Eff. Date: 7/1/73
Duration: 18 Mos.

The objective of this project is to develop an electrical generator and electrolysis unit suitable for a wind energy conversion system. Specific goals include (1) to design, fabricate and test a 10 kw electrical generator suitable for a wind conversion system, (2) to design, fabricate and test a 10kw electrolysis unit suitable for a wind conversion system, and (3) to perform a systems study of a wind energy conversion system incorporating the above components.

Solar energy sustains the winds. It is calculated that the power potential in the winds over the continental U.S., the aleutian arc and the Eastern seaboard is about 1011 kilowatts electric. Winds are remarkably repeatable and predictable. The momentum in moving air can be extracted by momentum-interchange machines located in suitable places such as plains, valleys, and along the continental coastal shelves. A desirable windpower system would incorporate a storage and a peaking capability, thereby being able to span between the variable wind and the patterned electricity consumer demand. This project is concerned with developing two key components in such a windpower system, i.e., the electrical generator to convert the variable shaft power into either constant frequency ac power or dc power to run an electrolysis cell which, in turn, would generate hydrogen and oxygen for storage and reconversion on demand.

NSF/RANN Solar Energy Grant: GI–39115
Granted: 5/17/73
Institution: Carnegie-Mellon University
Principal Investigator: Abrahim Lavi
Project Title: Conference on Power Generation from Ocean Temperature Difference

A conference on the generation of electric power by utilizing the temperature differential in tropical oceans will be held at Carnegie-Mellon University in order to exchange information among present researchers and potential contributors to this scheme of power generation and utilization. The participants will include (1) engineers and scientists presently supported by NSF–RANN programs and other governmental organizations and (2) specialists from government, industry and universities on the generation, transmission and utilization of Solar Sea Power Plants (SSPP). The conference will be a two day affair. The first day will be devoted to the presentation of various schemes and proposals for the solution of important technical problems in a SSPP. The second day, the participants will break into small working groups for more detailed and substantive discussions of specific problem areas. 500 copies of the conference paper summaries and discussions will be made available to attendees and NSF six weeks after the conference.

NSF/RANN Solar Energy Grant: GI–39114
Granted: 5/21/73
Institution: Carnegie. Mellon University
Principal Investigator: Clarence Zener
Project Title: Solar Power Ocean-Based Plants
Amount: $190, 000
Eff. Date: 6/1/73
Duration: 18 mos.

The objective of this project is the investigation of solar power systems based upon thermodynamic cycles of heat engines utilizing the natural energy resource system of ocean temperature differences. These power plants could produce electricity or storable fuel, e.g., hydrogen, while also producing large quantities of fresh water. The operation of these power systems depends upon use of the enormous quantities of warm ocean surface water, warmed by the sun particularly in tropical oceans and the Gulf Stream, for the boiler heat and the use of deep, cold water at the same location, due to deep currents from the earth's poles, for the condenser side of a heat engine. Though the temperature difference between boiler and condenser gives rise to small carnot and practical conversion efficiencies, preliminary designs and economic analysis indicate that the potential for economic power systems should be investigated further. This project will develop computer-based analytical models for technical and economic analyses of components and subsystems of the most important approaches to these power systems. A system model for analysis and optimization of power systems will be developed to undertake parametric analysis and to obtain minimum power costs. Sensitivity analyses of system parameters on performance and power costs will also be done. The project will include studies of heat exchangers, turbine-generators, and possible effects of the ocean environment.

NSF/RANN Solar Energy Grant: GI–34979
Granted: 2/9/73
Institution: University of Massachusetts
Principal Investigator: William E. Heronemus
Project Title: Ocean Sited Power Plant
Amount: $25, 200
Eff. Date: 2/15/73
Duration: 18 mos.

This project provides support for additional work on one of the two exploratory research tasks supported initially under GI–34979. The augmented effort will be applied to marine system conceptualizations and feasibility studies of power generation from ocean temperature differences where the boiler and condenser temperatures are about 75–85 degrees F (tropical surface waters) and 35–45 degrees F (bottom waters below 2000 feet), respectively. The goal of the research is to determine the technical and economic feasibilities of a complete system, including hull designs and anchoring, that is designed around a selected heat engine and working fluid. All components of a system will be conceptualized and evaluated including hulls, heat exchangers, pumps, pipes, electrolysis of water to hydrogen fuel, etc. for a 100–400 Mw central power station moored in the Gulf Stream. An estimate of the cost of a complete system will be developed. The augmented project will develop additional system information and data related to

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selection of heat engine working fluids, associated turbine design, design of heat exchangers, analysis of cold water intake piping and power requirements, water desalting equipment, and preparation of cost estimates for turbomachinery and heat exchangers.

NSF/RANN Solar Energy Grant: GI–39240
Granted: 5/4/73
Institution: International Solar Energy Society
Principal Investigator(s): Cherry, W.R.—Chairman
Project Title: Printing of the 1973 International Solar Energy Congress Abstracts
Amount: $10,000
Eff. Date: 6/1/73
Duration: 6 Mos.

An international meeting on Solar Energy will be held in Paris, France on July 2–6, 1973. The funds from this grant are to be used to support in part the printing of 700 sets of abstracts of the approximately 350 papers selected for the meeting. One hundred sets of the abstracts are to be submitted to the National Science Foundation for its use and the other 600 sets are to be given to the attendees of the congress. The primary purpose of this grant is the dissemination of information on solar energy research. Each abstract will have printed at the bottom, "The printing of this document was supported by a grant from the Research Applications Directorate of the National Science Foundation, an agency of the U.S. Government."

NSF/RANN Solar Energy Grant: GI–32488
Granted: 11/21/72
Institution: University of Maryland
Principal Investigator: Redfield W. Allen
Project Title: Solar Energy Panel
Amount: $24,600
Eff. Date: 9/15/72
Duration: 6 mos.

The objective of this project is the evaluation of the effects of system options and actual process factors on the performance and optimization of solar absorption air conditioning systems. Specific goals include (1) The development of parametric performance factors for ideal and actual system operation at various thermodynamic conditions, (2) evaluation of the thermal heliotrope for use with sun-tracking collectors, (3) the thermodynamic and economic optimization of the collector and absorption refrigeration systems.

In a recent study, the NSF/NASA Solar Energy Panel concluded that, with a substantial development program, by the year 2000 solar energy could economically provide up to 10% of the total building heating and cooling energy requirements. This represents a major impact on the building industry, with an annual fossil fuel savings of approximately $2.1 billion, based on a fuel cost of $\$1.00/10^6$ Btu. While the energy requirements for air conditioning are a small fraction of the total annual building heating and cooling energy demand, the rapidly growing air conditioning power demands periodically tax the peak load capacity of regional power networks. This situation gives added emphasis to the need to develop solar powered air conditioning. Once solar air conditioning becomes a marketable product it will be possible to combine it with solar heating, with associated savings in initial cost. This project to conduct optimization studies of solar power air conditioning systems, should define limitations of present technology and point to ways of lowering cost and improving performance.

NSF/RANN Solar Energy Grant: C–831
Granted: 7/2/73
Institution: The Mitre Corporation
Principal Investigator: Richard S. Greeley
Project Title: System Study of the NSF Solar Energy Research Program
Amount: $152,334
Eff. Date: 7/1/73
Duration: 4 mos.

The proposed objectives of this contract are to perform a system analysis of the NSF Solar Energy Research Program, and based on the analysis, develop a recommended five-year preliminary program development plan emphasizing proof-of-concept experiments and the supporting advanced research required in the program. The study will identify major issues, establish priorities among the various program elements and provide cost-benefit analysis.

NSF/RANN Solar Energy Grant: GI–37124
Granted: 2/12/73
Institution: University of Pennsylvania
Principal Investigaror: Martin Wolf
Project Title: Solar Energy Research Conference
Amount: $11,000
Eff. Date: 2/1/73
Duration: 05 mos.

A grantee solar energy research conference will be held at the University of Pennsylvania February 6 and 7, 1973, for the purpose of exchanging information on NSF-RANN sponsored solar energy research projects. The objectives of the conference are:
(1) Information exchange on research project accomplishments;
(2) Identification of special problem areas in research
(3) Coordination of solar energy research;
(4) Improvement of communications with the user community;
(5) Contribution to solar energy research program planning; and to
(6) Foster cooperation in applications of solar energy research.
The program will include short presentations by representatives from each research project, and will provide discussions periods to address such general questions as coordination of solar energy research projects, continuing information exchange, communications with the user community, contributions to program planning and operation, and cooperation in solar energy applications.

Participants from other interested Federal agencies will be invited to attend.

NSF/RANN Solar Energy Grant: GI–34992
Granted: 6/26/72
Institution: Case Western Reserve University
Principal Investigator: L. O. Krampitz
Project Title: Hydrogen Production by Photosynthesis and Hydrogenase Activity—An Energy Source
Amount: $150,000
Eff. Date: 7/1/72
Duration: 18 Mos.

The objective of this research project is to investigate the feasibility for direct formation of hydrogen gas through bioconversion of solar energy, employing the photosynthetic apparatus of green plants and algae and the catalytic activity of the enzyme, hydrogenase. Under the stimulation of light the photosynthetic apparatus in chlorophyll and other accessory pigments can raise the oxidation-reduction potential of the electrons released from water to a level as much as 0.3 volt more negative than the hydrogen electrode. Therefore, it is thermodynamically possible to couple the reducing potential of these electrons with hydrogenase to bring about the reduction of hydrogenions to form hydrogen gas. The hydrogenases may exist either endogenously in algae or exogenously in bacterial sources. Several possibilities will be investigated for accomplishing the required coupling of photosynthetically reduced substances and appropriate hydrogenase activity.

NSF/RANN Solar Energy Grant: GI–32726
Granted: 4/1/72
Institution: Rutgers, the State University
Principal Investigator: Wayne A. Anderson
Project Title: An Improved Schottky Barrier Photovoltaic Diode for Solar Energy Conversion
Amount: $16,000
Eff. Date: 4/1/72
Duration: 18 mos.

The objective of this project is do develop a more efficient and cheaper photovoltaic device using Schottky Barrier Diode (SBD) principles. This project includes calculations to determine the optical properties and to select thicknesses of various metal coatings on semiconductor substrates for proposed designs of SBD solar cells; the testing of metal films (e.g., Au-Cr) for optical and electrical properties; the fabrication of solar cells using evaporation and sputtering techniques; and testing to evaluate the efficiency of the resulting SBD solar cells. Preliminary calculations and experiments indicate that SBD principles can improve the efficiency of a solar cell by increasing the fraction of photons that optically reach the active volume and by increasing the usable photon energy range for generating free carriers in the metal or semiconductor films.

NSF/RANN SOLAR ENERGY RESEARCH GRANTS AND CONTRACTS IN FISCAL YEAR 1974

Institution and program manager	Title and grant No.	Amount	Duration (mos.)	Effective date
Texas A&M University (R. R. Davison)	Further development of the compressed-film floating-deck solar water heater (GI-39584).	$36,900	12	Sept. 1, 1973
University of Delaware (K. W. Boer)	Direct solar energy conversion for large scale terrestrial use (GI-34872).	294,100	12	Sept. 10, 1973
Colorado State University (G. Lof)	Design, construction, and testing of residential solar heating and cooling system (GI-40457).	238,000	24	Sept. 1973
Indiana University/Bloomington (A. San Pietro).	Workshop on hydrogen production by biophotolysis (GI-40253).	13,000	12	Aug. 21, 1973
Arthur D. Little, Inc. (J. B. Berkowitz)	Technology assessment of terrestrial solar energy resources development (C-835) (ERPA).	246,664	12	Sept. 12, 1973
Systems Group of TRW Inc., (J. E. Boretz).	Solar heating and cooling of buildings (C-853) (PTP).	485,652	8	Oct. 9, 1973
Westinghouse Electric Corp. (R. E. Kirby).	Conduct phase 0 of a multiphased solar heating and cooling of buildings program (C-854) (PTP).	503,085	8	Do.
General Electric Co. (A. D. Cohen)	The solar heating and cooling of buildings (C-855) (PTP).	547,322	8	Do.
University of Houston (J. R. Howell and R. B. Bannerot).	The evaluation of surface geometry modification to improve the directional selectivity of solar energy collectors.	[1] 53,800	12	Dec. 1, 1973
National Bureau of Standards (J. E. Hill).	Development of methods of evaluation and test procedures for solar collectors and storage devices.	[1] 76,700	6	Nov. 1, 1973
Hittman Associates, Inc. (Wm. P. Menchen).	Assessment of Rankine cycle engines for potential application to solar powered cooling of buildings.	[1] 49,200	5	Do.
Jet Propulsion Laboratory/NASA (R. Lutwack).	Assessment of photovoltaic conversion of solar energy for terrestrial applications (AG-485).	34,000	6	Sept. 1, 1973
Aerospace Corp. (A. B. Greenberg)	Solar thermal conversion mission analysis	[1] 250,000	9½	Nov. 1, 1973
G. T. Schjeldahl Co. (R. A. Stickley)	Solar power array for the concentration of energy.	[1] 260,100	12	Do.
Associated Universities, Inc. (V. Bremenkamp).	Support of U.S.-U.S.S.R. cooperation in solar and geothermal energy (C-847).	120,000	11	Aug. 1, 1973
University of Maryland (R. Allen)	Solar Energy Panel (GI-32488-3)	15,000	6	
NOAA (L. Machta)	Workshop on solar radiation monitoring for solar energy applications.	[1] 19,040	6	Nov. 15, 1973
McDonnell Douglas Astronautics Co.-West (G. F. Pittinato).	Elimination or control of material problems in water heat pipes.	[1] 189,450	12	Dec. 1, 1973

[1] Estimated.

NSF/RANN Solar Energy Grant: GI-39584
Granted: 7/19/73
Institution: Texas A&M University
Principal Investigator: Richard R. Davison
Project Title: Further Development of the Compressed-Film Floating-Deck Solar Water Heater
Amount: $36,900
Eff. Date: 9/1/73
Duration: 12 mos.

A solar heater, invented[1] by the investigators, will be further developed as a potentially low-cost solar energy collector. The collector employs a thin compressed film of water on a floating insulated deck so that rapid response to solar conditions and low cost objectives are realizable. The objectives of the proposed research are: 1) to make performance runs using a wide variety of conditions so heat performance can be corrected in terms of solar, meterological and configurational parameters; and 2) to test various design details and materials to optimize these with respect to cost and performance.

Two heaters will be built, one to be used strictly for performance correlations and the other to test various design configurations.

[1] Under study for Office of Saline Water. Patent assigned: United States of America.

NSF/RANN Solar Energy Grant: GI–34872
Granted: 9/10/73
Institution: University of Delaware
Principal Investigator: Karl W. Böer
Project Title: Direct Solar Energy Conversion for Large-Scale Terrestrial Use
Amount: $294,100
Eff. Date: 9/10/73
Duration: 12 mos.

This research is the renewal proposal for the second year of a project directed to further understanding and development of CdS/Cu_2S solar cells to obtain longer-life, higher performance, more economical cells for applications in large and small-scale solar energy conversion systems. The principal objectives are (1) improved understanding of the basic properties and conversion mechanics of CdS/Cu_2S cells, (2) improved understanding of the effect of every single process step on the cell mechanism and, (3) lifetime testing and development of reliable accelerated test methods.

NSF/RANN Solar Energy Grant: GI–40253
Granted: 8/20/73
Institution: Indiana University/Bloomington
Principal Investigator: Anthony San Pietro
Project Title: Workshop on Hydrogen Production by Biophotolysis
Amount: $13,000
Eff. Date: 8/21/73
Duration: 12 mos.

The objectives of this research workshop are, first to discuss the development of biosolar conversion technology to produce practical fuels and, secondly, to encourage an information exchange necessary to achieve this goal. Three major research questions will have to be considered at this conference.

These are:

1. What are the requirements to stabilize individually each photosystem (of photosynthesis) or to stabilize collectively both photosystems? In concert with this question, the efficiency of the bio-solar conversion process will also be considered in depth.
2. What should be the nature of the reduce product of the biolsolar conversion process? Should it be hydrogen gas?
3. If the bio-photolysis of water to produce hydrogen is the process of preference, the availability of an oxygen-insensitive hydrogenase is absolutely necessary. Do such hydrogenases exist in nature or will it be necessary to resort to genetic manipulation to provide such an enzyme?

The in-depth assessment of these three questions will require a conference of two days length. These discussions will hopefully formulate a plan of approach designed to provide sufficient additional information to allow for a technological assessment of the problem some five or so years hence. During this initial period, the goal will be the evaluation of the theoretical and practical factors relating to successful application of the solar conversion process using a biological photocatalyst.

Five hundred copies of the conference paper summaries and discussions will be made available to attendees and the NSF six weeks after the conference.

NSF/RANN Solar Energy Grant: GI–40457
Granted: 9/ /73
Institution: Colorado State University
Principal Investigator: George Lof
Project Title: Design, Construction, and Testing of Residential Solar Heating and Cooling System
Amount: $238,000.
Eff. Date: 9/ /73
Duration: 24 mos.

This project is a two-year experimental development of a fully operational residential heating and cooling system based on solar energy as the principal energy supply. No completely integrated system has ever been operated in this country. The objective is to design, build, and test a reliable and economical, integrated solar heating and cooling system. A lithium bromide absorption air conditioner, previously tested with a solar energy supply at the University of Wisconsin by personnel associated with this project, will be utilized for the cooling cycle. The computer program developed in the Wisconsin project, "A Simulation

Study of Solar Heating and Cooling for the United States," will be used to optimize the design of this particular system of heating, cooling and water heating, and detailed studies on the technical performance and economics of this system wil be conducted. Design will require six months, construction—six months, preliminary and final performance testing—one year. These facilities are then to be used for testing components and complete systems for solar heating and cooling developed by other NSF grantees and commercial manufacturers.

NSF/RANN Solar Energy Grant: C–853
Granted: 9/12/73
Institution: Arthur D. Little
Principal Investigator: Joan Berkowitz
Project Title: Technology Assessment of Terrestrial Solar Energy Resource Development
Amount: $246, 664
Eff. Date: 9/12/73
Duration: 12 mos.

ADL will conduct a technology assessment of terrestrial solar energy resource development in order to identify and examine direct and indirect effects, impacts, and consequences of the development and use of energy systems that include substantial solar components. The program will be subdivided into a number of integrated tasks:

Task I—Selection of Terrestrial Solar Technologies for Assessment.
Task II—Identification of Possible Points of Impact.
Task III—Identification of Parties at Interest.
Task IV—Analysis of Impacts.
Task V—Alternate Energy Strategies.
Task VI—Definition of Public Policy Options.
Task VII—Dissemination and Utilization of Results.

NSF/RANN Solar Energy Grant: C–853
Granted: 9/28/73
Institution: TRW Systems Group
Principal Investigator: J. E. Boretz
Project Title: Solar Heating and Cooling of Buildings—Phase O Study
Amount: $485, 652
Eff. Date: 10/9/73
Duration: 8 mos.

This is the initial phase of a multiphased program whose oblective is to advance the widespread use and availability of systems utilizing solar energy for heating, cooling and the hot water needs of buildings by proving that such systems are economically justifiable, technically feasible, and socially acceptable.

This prolect is one of three independent study efforts with each contractor team working independently to bring widely diverse experience and expertise to bear on the problem, and to assist in the development of a broad industrial base.

The objective of the Phase O study will be to establish the program feasibility and provide the basis of planning the later phases of the program by: 1) Developing the heating, cooling and hot water requirements of all building types in all climatic regions of the U.S. 2) Conceptualizing integrated solar energy systems to meet the requirements and utilizing conventional fuels to supplement the solar energy systems. 3) Determining the economic viability of the various systems and applications, recommending the systems which are viable and have an impact for proof-of-concept experiments. The experiments will be conducted in subsequent phases under separate contracts.

NSF/RANN Solar Energy Grant: C–854
Granted: 9/28/73
Institution: Westinghouse Electric Corp.
Principal Investigator: R. E. Kirby
Project Title: The Solar Heating and Cooling of Buildings—Phase O Study
Amount; $503.085
Eff. Date 10/9/73
Duration; 8 mos.

This is the initial phase of a multiphased program whose objective is to advance the widespread use and availability of systems utilizing solar energy for heating, cooling and the hot water needs of buildings by proving that such systems are economically justifiable, technically feasible, and socially acceptable.

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NSF/RANN Solar Energy Grant: C–855
Granted: 9/28/73
Institution: General Electric Co.
Principal Investigator: A. D. Cohen
Project Title: The Solar Heating and Cooling of Buildings
Amount: $547,322
Eff. Date: 10/9/73
Duration: 8 mos.

This is the initial phase of a multiphased program whose objective is to advance the widespread use and availability of systems utilizing solar energy for heating, cooling and the hot water needs of buildings by proving that such systems are economically justifiable, technically feasible, and socially acceptable.

This project is one of three independent study efforts with each contractor team working independently to bring widely diverse experience and expertise to bear on the problem, and to assist in the development of a broad industrial base.

The objective of the Phase O study will be to establish the program feasibility and provide the basis of planning the later phases of the program by: 1) Developing the heating, cooling, and hot water requirements of all building types in all climatic regions of the U.S. 2) Conceptualizing integrated solar energy systems to meet the requirements and utilizing conventional fuels to supplement the solar energy systems. 3) Determining the economic viability of the various systems and applications, recommending the systems which are viable and have an impact for proof-of-concept experiments. The experiments will be conducted in subsequent phases under separate contracts.

NSF/RANN Solar Energy Grant:
Granted:
Institution: University of Houston
Principal Investigators: John R. Howell and Richard B. Bannerot
Project Title: The Evaluation of Surface Geometry Modification to Improve the Directional Selectivity of Solar Energy Collectors
Amount: $53,800
Eff. Date: 12/1/73
Duration: 12 mos.

The performance of the flat-plate collector can be greatly enhanced with the use of spectrally (wave length) and/or directionally selective surfaces. Since the sun's radiation approximates that from a 5600°K black body, it possesses significantly different spectral characteristics from those exhibited by the radiation emitted from the collector surface (around 400°K). If surface coatings can be selected which absorb efficiently in the shorter wavelength region and emit poorly in the longer wavelength region, a collector surface will result with efficiency greater than that of a black body. Directional selectivity can also be very useful. The preferred absorption direction of the collector surface can be aligned to take advantage of this fact. In addition, if the surface emits directionally, it may emit only a fraction of that energy emitted by another otherwise similar diffuse surface.

This project will examine two model geometrics to determine the optimum parameters that will maximize the directional selectivity. The choice of the models will be based on a trade-off study considering cost and predicted performance. The two models will be constructed and tested for their actual radiative behavior. This behavior will then be compared with the predicted values. The radiative properties necessary to the analysis will be determined experimentally. This experimental work will be carried out using existing laboratory equipment through a cooperative agreement with the NASA Johnson Spacecraft Center.

NSF/RANN Solar Energy Grant:
Granted:
Institution: National Bureau of Standards
Principal Investigator: James E. Hill
Project Title: Development of Methods of Evaluation and Test Procedures for Solar Collectors and Storage Devices.
Amount: $76,700
Eff. Date: 11/1/73
Duration: 6 mos.

The objective of this project is to identify those parameters which are inherent in the equipment design and which should be covered by the testing and rating procedures, and to develop test procedures what will equitably compare different designs in relation to representative standard design climate conditions. The testing procedure should have the characteristics of reasonable accuracy and reproducibility, be easily understood, and be similar in form to testing and rating procedures for other heating systems. The project will consist of three tasks: (1) review of the methods of analysis that have been proposed in the past for evaluation of solar equipment; (2) review of current procedures for testing and reporting performance data of solar collectors and storage devices; and (3) the development of recommended test methods and rating procedures. A follow-on project may be the experimental verification of the recommended test methods and rating procedures, however this step is not included in the initial project.

NSF/RANN Solar Energy Grant:
Granted:
Institution: Hittman Associates, Inc.
Principal Investigator: Wm. P. Menchen
Project Title: Assessment of Rankine Cycle Engines for Potential Application to Solar Powered Cooling of Buildings
Amount: $49,200
Eff. Date: 11/1/73
Duration: 5 mos.

The Clean Air Amendments of 1970 prompted renewed and vigorous attempts to develop a "steam" engine for automotive propulsion since such a system has the potential of exceeding the stringent emission standards set by EPA for automobiles. Many engine designs have been proposed and built for the automotive application since 1970. The work proposed under this project is to examine these engines and to project their potential performance under the conditions of a heat source from a solar energy collector and load from a building cooling plant. The basic components of a Rankine engine are a boiler, expander, pump, condenser, and the working fluid (and in some cases, a recuperator). In an automobile, the boiler, pump, and condenser are critical components whose size and weight significantly influence performance. In a solar energy-Rankine engine cooling system these limitations may not exist; however, the temperature of the heat source and the temperature differential between source and condenser may be much smaller.

This study will review and compare the performance characteristics of the Rankine engines developed recently. Solar energy system components will be characterized as they influence the quantity and quality of thermal energy that can be delivered to the heat exchanger in the Rankine engine boiler or to the Rankine engine directly if the solar collector serves as a boiler. The performance of the various Rankine engines will be projected in terms of solar energy system operating conditions to provide insight into problems requiring further research and development.

NSF/RANN Solar Energy Grant: (AG–485)
Granted: 10/3/73
Institution: Jet Propulsion Lab./NASA
Principal Investigator: Ralph Lutwack
Project Title: Assessment of Photovoltaic Conversion of Solar Energy for Terrestrial Applications
Amount: $34,000
Eff. Date: 9/1/73
Duration: 6 mos.

The objective of this project is to provide a detailed technical assessment of the photovoltaic conversion of solar energy for terrestrial applications. Recommendations will be made concerning research and development programs necessary to develop the full potential of this solar energy conversion technology. These

recommendations will contain task objectives, milestones, program phasing, implementation approach and required levels of support. A workshop on photovoltaic energy conversion will be organized to provide a sound basis for this assessment. A report on the conclusions of this project will be prepared for widespread dissemination.

NSF/RANN Solar Energy Grant:
Granted:
Institution: Aerospace Corporation
Principal Investigator: A. B. Greenberg
Project Title: Solar Thermal Conversion Mission Analysis
Amount: $250,000
Eff. Date: 11/1/73
Duration: 9½ mos.

The objective of this analysis is to provide a basis for selecting the most promising missions, i.e. (powerplant scale and function) for solar thermal conversion systems in the Southwestern United States for the period 1980–2000. This effort will apply the methodology which has been developed for assessing the role of solar thermal conversion in large scale production of electrical energy throughout the Southwestern U. S. and develop and apply methodology necessary to assess the role of total solar energy systems in that region. The study approach will include: 1) Collection and correlation of regional solar insolation and climatological data over the Southwestern U. S., 2) Review, analysis and projection of electrical and thermal demands in the region for the time period 1980–2000, 3) Application of the previously developed methodology to evaluate the potential of municipal or remote central station solar thermal power plant, and assess the applicability of such power plants to the existing power grid, 4) Extension of the methodology to combine electrical/thermal service systems for industrial, community, military base or municipal applications, 5) Development of system and subsystem requirements, and 6) Evaluation of siting opportunities and constraints in the Southwestern U. S.

NSF/RANN Solar Energy Grant:
Granted:
Institution: G. T. Schjeldahl Company
Principal Investigator: Ross A. Stickley
Project Title: Solar Power Array for the Concentration of Energy
Amount: $260,100
Eff. Date: 11/1/73
Duration: 12 mos.

The objective of this project is to estimate the technical and economic performance of a heliostat (steerable reflector) array-central receiver solar thermal conversion system operating in a hybrid configuration with a conventional fossil fuel generating system. This approach is one wherein solar energy is utilized when available in a so-called "energy displacement" mode; thus minimizing or eliminating the requirement for energy storage and simultaneously reducing fossil fuel usage. The scope of the effort includes: 1) definition of hybrid power plant functional, performance and operation requirements, 2) conceptual design of alternative systems, 3) development of analytical tec-niques for estimating the incident solar flux on the receiver and the heat transfer to the receiver working fluid, 4) defining a baseline system design and 5) conducting materials analysis and specimen testing to define the applicability of metallized thin film reflective materials to heliostat reflectors.

NSF/RANN Solar Energy Grant: (C–847)
Granted: 10/10/73
Institution: Associated Universities, Inc.
Principal Investigator: Victor Bremenkamp
Project Title: Support of U.S.-U.S.S.R. Cooperation in Solar and Geothermal Energy
Amount: $120,000
Eff. Date: 8/1/73
Duration: 11 mos.

The U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation approved action programs of direct cooperation in six general areas of strong mutual interest and benefit to both countries. The six areas identified are energy, computer applications to management, agricultural research, microbiological

synthesis, chemical catalysis, and water resources. This project provides support for the U.S. activities in two subgroups—solar energy and geothermal energy.

NSF/RANN Solar Energy Grant: GI–32488–3
Granted:
Institution: University of Maryland
Principal Investigator: Redfield Allen
Project Title: Solar Energy Panel
Amount: $15,000
Eff. Date:
Duration: 6 mos.

Under a previous grant, the University of Maryland organized and conducted two workshops: The Solar Thermal Energy Conversion Workshop and the Solar Heating and Cooling for Buildings Workshop.

The objective of this supplementary grant is to provide support for the preparation, publishing and distribution of the reports of these workshops, as well as the distribution of the remaining copies of the Solar Energy Panel Report.

NSF/RANN Solar Energy Grant:
Granted:
Institution: National Oceanic & Atmospheric Administration
Principal Investigator: Lester Machta
Amount: $19,040
Eff. Date: 11/15/73
Duration: 6 mos.

A workshop will be conducted to define the needs for, and availability of, geophysical data (mainly on solar insolation) for solar energy applications. Attendees will be drawn from the solar energy user community, from meteorologists, and from persons specializing in the instrumentation, measurement, and dissemination of these data or monitoring devices. Emphasis will be placed upon the status of existing data, how to make the best use of such data, present monitoring capabilities, and the development of priorities for obtaining appropriate data for solar energy requirements in the future.

NSF/RANN Solar Energy Grant:
Granted:
Institution: McDonnell Douglas Astronautics Company-West
Principal Investigator: G. F. Pittinato
Project Title: Elimination or Control of Material Problems in Water Heat Pipes
Amount: $189,450
Eff. Date: 12/1/73
Duration: 12 mos.

The objective of this research project is to determine an effective combination of materials, fabrication methods, and operating procedures for a water heat pipe that will provide satisfactory long life operating performance for temperatures up to 310° C. The research project will be conducted in three subphases. These subphases will: 1) Define the most effective combination of design, materials fabrication methods, and operating procedures that eliminates or minimizes noncondensable gases in water heat pipes, 2) Fabricate and test a 15–20 meter long water heat pipe that utilizes the procedures established in (1) and is projected to be cost effective and compatible with full-scale production and preparation methods and 3) Establish material and fabrication process specifications applicable to full-scale solar collector heat pipe life test.

U.S. ENVIRONMENTAL PROTECTION AGENCY,
Washington, D.C., December 21, 1973.

Hon. SAM J. ERVIN, JR.,
Chairman, Committee on Government Operations,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in response to your request for the views of the Evironmental Protection Agency on S. 2744, a bill "To reorganize and consolidate certain functions of the Federal Government in a new Energy Research and Development Administration and in a Nuclear Energy Commission in order to promote more efficient management of such functions."

The bill would establish an independent executive agency to be known as the Energy Research and Development Administration (ERDA). The bill would authorize the Administrator of ERDA to engage in research and development activity with respect to (1) all energy sources; (2) the commercial feasibility of energy sources and utilization technologies; (3) the utilization of energy from fossil, nuclear, solar, geothermal and other energy sources; and (4) environmental, biomedical, physical, and safety factors. The bill would also authorize the Administrator to monitor other relevant public and private research and development activities, to support cooperative research and development projects, and to disseminate scientific and technical information concerning the manufacture or development of energy.

The bill would transfer to ERDA various energy-related functions of the Atomic Energy Commission, the Department of the Interior, the National Science Foundation, and the Environmental Protection Agency. With respect to our Agency, the bill would transfer to ERDA those functions that relate to (1) the development and demonstration of alternative automotive power systems and (2) the development and demonstration of precombustion, combustion, and postcombustion technologies to control emissions of pollutants from stationary sources using fossil fuels.

Finally, the bill would rename the Atomic Energy Commission the Nuclear Energy Commission and allow it to cont nue to perform the licensing and related regulatory functions of the AEC which are excepted from transfer to ERDA. The bill would also authorize the Nuclear Energy Commission to conduct the necessary research for the discharge of its licensing and regulatory functions.

The Environmental Protection Agency supports the enactment of S. 2744.

We believe that the proposed Energy Research and Development Administration is sorely needed to lead the national effort to demonstrate our potential for energy self-sufficiency. By incorporating most of the energy-related research and development activities now being conducted by several Federal establishments, including our Agency, ERDA would constitute a single structured, organized and adequately supported effort which would be able to explore a wide range of potential energy sources and to develop an integrated energy strategy to meet our future energy needs.

From an environmental protection perspective, we believe that we must make every effort to assure that the new energy technologies that ERDA develops are designed to cause minimal adverse environmental impact. ERDA, we feel, should balance the environmental benefits and drawbacks of these alternative energy sources with a view toward developing an energy program that would have the least environmental detrimental effect on our environment. In this regard, we expect to consult and work closely with all levels in ERDA to give them the benefit of our perspectives, to inform them of needs for pollution control technology, and to comment on the environmental aspects of the energy technology they develop.

The bill would transfer to ERDA some of our resources now committed to the development and demonstration of alternative automotive power systems, as well as to the development and demonstration of precombustion, combustion, and postcombustion technology to control emissions of pollutants from stationary energy sources using fossil fuels. We support these transfers because we believe that there is a definite need to advance the technology in these areas from the standpoint of improved efficiency of operation and fuel economy. At the same time,

it is our understanding that EPA will continue to conduct research and technical assessment activities with respect to stationary energy sources as well as mobile sources in order to meet its standard-setting and regulatory responsibilities, and will have the resources to maintain knowledge of control technology, including the control technology that ERDA will be responsible for developing and demonstrating. We also understand that EPA will retain the resources to carry out research and development related to the responsibility it retains for assuring that the adverse environmental impact of energy technology is kept to a minimum; also that EPA will retain the responsibility for development of pollution control technology for non-energy industrial and domestic pollution sources.

In the final analysis, we believe that there is no reason why energy technology development should compete with environmental protection because, if properly pursued, both goals are complementary. To realize both goals, however, we must champion and balance both objectives. We feel that ERDA, in conjunction with our Agency, can accomplish this dual objective and, as a reuslt, we support the enactment of S. 2744.

The Office of Management and Budget advises that there is no objection to the submission of this report from the standpoint of the President's program.

Sincerely yours,

JOHN QUARLES,
Deputy for Russell E. Train.

THE NATION'S ENERGY FUTURE

A REPORT TO RICHARD M. NIXON PRESIDENT OF THE UNITED STATES

1 DECEMBER 1973

Submitted by Dr. Dixy Lee Ray
Chairman, United States Atomic Energy Commission

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OFFICE OF THE CHAIRMAN

December 1, 1973

The President
The White House

Dear Mr. President:

In response to your directive of 29 June of this year, viz:

> " . . . I am directing the Chairman of the Atomic Energy Commission to undertake an immediate review of Federal and private energy research and development activities, under the general direction of the Energy Policy Office, and to recommend an integrated energy research and development program for the Nation. . . . By December 1 of this year, I am asking for her recommendations for energy research and development programs which should be included in my fiscal year 1975 budget."

I am pleased to present this Report.

As requested, the Report was developed under the general guidance of the Energy Policy Office. It has also benefited from the active participation of those Federal Agencies most concerned with energy research. Additionally, there has been widespread consultation with representatives of the private sector, including a broad range of energy industries. A more detailed description of the procedures that were followed and a listing of those persons most directly involved are attached hereto.

Any merit the Report may have deserves to be widely shared with those who devoted their time, energy, and talent to its development. Any shortcomings are my responsibility alone. Formal concurrence in the recommendations was not requested from either individuals or agencies; the final recommendations are based on all

the information gathered and result from my considered judgment of the kind of thoughtful, well-considered energy research and development program that this Nation urgently needs to pursue.

Considerations for using today's technology to meet and overcome the present energy crisis, and to be responsive to "Project Independence", are being submitted separately.

I earnestly hope that this Report will be helpful in your efforts to mobilize the Nation's resources toward the attainment of a capacity for energy self-sufficiency by 1980. I believe that, in surmounting this challenge, the Nation can emerge stronger and more free than ever before to pursue with renewed vigor its high aims of domestic and international peace and well being.

Respectfully yours,

Chairman

Attachment

ATTACHMENT

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT PROGRAM

This report is based upon the results of several major and somewhat independent efforts:

- A group of Energy Workshops, organized under the sponsorship of Cornell University, considered the major directions and overall framework required for a national program. Specific workshop topics and the membership of each are shown in Appendix C of the Report. The deliberations will be separately published.

- Sixteen Technical Review Panels were established. These were made up of 121 Federal employees from thirty-six Departments and Agencies assisted by 282 consultants from the private sector. More than 1100 specific proposals for the energy research and development program were reviewed and evaluated. Membership of the panels and the consultants employed are listed in Appendix C.

- Review of the results from the Workshops and the Technical Panels was conducted by an Overview Panel chaired by Mr. Stephen A. Wakefield, Assistant Secretary for Energy and Minerals, Department of the Interior. The membership included:

  Mr. William E. Simon, Deputy Secretary of the Treasury

  Dr. Beatrice E. Willard, Member, Council of Environmental Quality

  Dr. Betsy Ancker-Johnson, Assistant Secretary for Science and Technology, Department of Commerce

  Dr. Stanley M. Greenfield, Assistant Administrator for Research and Development, Environmental Protection Agency

Mr. William A. Anders, Commissioner, Atomic Energy Commission

Mr. Bruce T. Lundin, Director, Lewis Research Center, National Aeronautics and Space Administration

Mr. John P. Abbadessa, Controller, Atomic Energy Commission

The Overview Panel made specific recommendations on the composition of the ten billion dollar, five year program and on the fiscal year 1975 budget.

- A draft of the report was sent to more than 100 individuals for comment. It also went to all concerned government Departments and Agencies.
- I consulted personally with numerous leaders in government, industry, and the scientific community throughout the period of the Report's preparation.

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THE NATION'S ENERGY FUTURE

A REPORT TO

RICHARD M. NIXON

PRESIDENT
OF
THE UNITED STATES

1 DECEMBER 1973

Submitted by Dr. Dixy Lee Ray
Chairman, United States Atomic Energy Commission

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EXECUTIVE SUMMARY

Purpose:

The Report, directed by the President in his June 29, 1973, Statement on Energy, recommends:

- A national energy research and development (ER&D) program.
- A five-year, $10 billion Federal ER&D program.
- The FY 1975 Federal budget for ER&D.

Findings:

- Present energy problems stem, in large part, from the lack of a coordinated national ER&D program over the last 20 years. Only nuclear power has received sustained support at adequate levels.

- The requirement to regain and maintain energy self-sufficiency stems from conditions more fundamental than the current crisis. Worldwide energy shortages impend as energy-intensive industrial growth spreads and accelerates.

- The United States has the resources and technology for self-sufficiency. A properly directed, sustained national commitment can attain that goal.

- Five tasks are required to regain and sustain self-sufficiency, and simultaneous effort is urgently required on all five. Their contributions to self-sufficiency will begin to materialize in the order listed:

  Task 1. Conserve energy by reducing consumption and conserve energy resources by increasing the technical efficiency of conversion processes.

  Task 2. Increase domestic production of oil and natural gas as rapidly as possible.

  Task 3. Increase the use of coal, first to supplement and later to replace oil and natural gas.

  Task 4. Expand the production of nuclear energy as rapidly as possible, first to supplement and later to replace fossil energy.

  Task 5. Promote, to the maximum extent feasible, the use of renewable energy sources (hydro, geothermal, solar) and pursue the promise of fusion and central station solar power.

- The recommended program, based on what is now known, is both necessary and sufficient to maximize ER&D's contribution to the Nation's energy goals. Even so, 1985 is the earliest date by which self-sufficiency can reasonably be expected with this program.

- By 1980, the recommended ER&D program is expected to reduce oil imports to half (6 million barrels/day) of those currently projected. Other extraordinary measures will be required to restrict consumption, increase domestic production, or both by enough to displace the other half.

Recommendations:

- The national and Federal ER&D programs, FY 1975-1979, and the FY 1975 Federal ER&D budget are shown in the table below. (The FY 1974 Federal ER&D budget is shown for comparison.)

ER&D PROGRAM AND BUDGET RECOMMENDATIONS
($ Millions)

Self-Sufficiency Tasks	ER&D Programs, FY 1975-1979 Total Required	Private Expected	Federal Recommended	Federal ER&D Budget FY 1974 Planned	FY 1975 Recommended
1. Conserve Energy and Energy Resources	4,940	3,500	1,440	62.3	166.2
2. Produce Oil and Natural Gas	4,960	4,500	460	19.5	51.7
3. Produce and Use Coal	5,175	3,000	2,175	167.2	405.0
4. Produce Nuclear Energy	5,340	1,250	4,090	517.3	731.7
5. Use Other Sources, Pursue Future Prospects	2,085	250	1,835	123.0	217.5
TOTAL	22,500	12,500	10,000	889.3	1,572.1

- Establish an operational Energy Research and Development Administration not later than July 1, 1974, to plan and coordinate the total program and to direct the major share of the Federal program.

- Conduct a comprehensive program review at least annually, reallocating funds among programs as required. Increase the total program only if reallocations are insufficient to fund all highly promising prospects.

- Ensure full consideration of the energy consequences of all Federal actions taken to achieve nonenergy goals.

- Maximize private-sector involvement in the conduct, review, and evaluation of the Federal ER&D program, both to conserve Federal dollars and to speed up the application of technological advances.

- Initiate in FY 1975 a Synthetic Fuels Pioneer Program: privately funded construction, induced by loans or price guarantees, of several full-scale commercial plants for producing synthetic fuels from coal using existing technologies. Federal ER&D funds would be used to collect and disseminate engineering, economic, and environmental data that would serve as benchmarks for evaluating new developments. The program would lay the groundwork for a rapid expansion of domestic energy production capacity and focus ER&D effort, Federal and private, on highest priority problems.

- Accelerate ongoing work in three supporting programs that contribute to the goals of the recommended ER&D program:

1. Environmental Effects Research	$650 Million
2. Basic Research	300 Million
3. Manpower Development	50 Million
	$1000 Million

1

Purpose and Scope

This report is prepared in response to the President's directive in his June 29, 1973, energy message. Its purpose is to recommend:

- The national energy research and development program needed to regain and maintain energy self-sufficiency.
- The five-year, $10 billion Federal energy research and development program to supplement research and development expenditures expected from the private sector.
- The Fiscal Year 1975 Federal energy research and development budget.

Since the President's directive was announced, the Nation has become acutely aware that shortages of energy—especially oil—threaten its social, economic, and environmental priorities. The energy shortages of today and those projected for future decades stem, in part, from the lack of a coordinated national program for energy research and development over the past 10 to 20 years. Today's impending shortages impart a long overdue sense of urgency to the effort being launched to meet not only immediate requirements but also the growing needs of the years ahead.

The challenge posed by the immediate energy future carries with it an unparalleled opportunity to emerge better equipped than ever before to pursue the Nation's higher goals of domestic and international peace and prosperity. The Nation has long had the human and material resources to surmount the present challenge and seize its corresponding opportunity; the widespread awareness of the necessity to do so can now provide the essential will to convert its potential into practice.

This report is based on a series of studies carried out under the guidance of the Energy Policy Office in conjunction with Government departments and agencies having energy responsibilities. People from industry, foundations, and the academic community were also consulted, together

with other private citizens having responsibilities and acknowledged expertise in the energy field.

A number of issues had to be dealt with to limit the scope of the report to energy research and development. The most important were:

- The role of energy in our society.
- The relationship of energy research and development to energy policy.
- The distinction between energy research and development and energy production.
- The impact of research and development and other energy policy actions on the future of the Nation's energy system.
- The necessity to support energy development with an expansion of environmental effects research, basic research, and manpower development.
- The consequences of energy policies aimed at attaining other goals, such as economic growth, consumer protection, and land use.

THE ROLE OF ENERGY IN OUR SOCIETY

Energy is the *sine qua non* of a modern society's ability to do the things it wants to do. Such goals as maintaining the standard of living for a growing population, national security, improved quality of life, increased affluence, and increased assistance to less developed societies can only be attained with increasingly large amounts of energy. While lower energy costs allow a society more freedom of action in seeking its goals, the availability of energy is the first requirement of having any freedom of action at all.

RESEARCH AND DEVELOPMENT: ONE PART OF POLICY

Federal energy policy comprises those actions that aim to have a direct impact on the Nation's energy system by increasing supply, reducing demand, or changing production and use patterns. For example, one possible policy is to let the market determine what goes on in the energy system. Another policy is to intervene by rationing, price controls, mandatory allocations, price guarantees, and other nonmarket measures to change certain operations of the market and presumably the results for the economy.

The aim of Federal energy policy is to ensure that the Nation's ability to pursue its higher order goals is not unduly imparied by energy shortages.

To respond to current problems, policy-makers must select from among a set of actions limited by existing physical and institutional constraints. However, energy research and development actions can be taken now that will expand the range of actions that will be possible in the future.

By its nature energy research and development is an investment in the Nation's future. Numerous opportunities for research that would yield

early results exist and should be pursued vigorously; a major part of the recommended program is designed to remove obstacles to the attainment of energy self-sufficiency by 1980. Still, a program aimed only at the immediate future would be less than fully responsive to the Nation's needs. Major improvements in the energy situation can come only from sustained effort over an extended time because long lead times are required to improve the technologies for producing and using energy. Accordingly the recommended program was designed to meet the Nation's energy needs in the years beyond 1980, as well as to make the maximum possible contribution to the Nation's immediate energy goals.

RESEARCH AND DEVELOPMENT VS. PRODUCTION

Research and development activities extend from fundamental research on the properties of matter to successful demonstration on a commercial scale of the technical and economic feasibility of new processes. The application of new processes on a scale big enough to make a significant impact on the energy system is production, not research and development. A vigorous program for increasing energy production in the immediate future is urgently needed to move toward self-sufficiency. Such a program must rely primarily on existing technologies—not on research and development. Although some "quick fixes" of particular engineering problems in producing energy might be considered research and development, the bulk of the research and development program cannot be expected to make big differences in energy production rates in any short time.

The dividing line between research and development and production is not absolute; the two can be mutually supportive. Nothing identifies specific needs for immediate research and development attention more quickly than a major production program, and few actions can have as much short-term impact on a major production program as top priority research and development to remove production bottlenecks. The Manhattan Project of World War II is a classic example of how these two kinds of effort can be integrated and applied toward rapid attainment of a specific goal. Still, a balanced research and development program must not be limited only to efforts aimed at supporting immediate production programs; it must also include those efforts aimed at making possible the production programs that will be needed in the future.

RESEARCH AND DEVELOPMENT, POLICY, AND THE NATION'S ENERGY FUTURE

The national energy research and development program begun now and carried out over the next few years is a principal vehicle for shaping the evolution of the Nation's energy system. What is done and not done in that program will define the technological boundaries of future energy policy choices. Accordingly, obtaining agreement on how the energy system should evolve is the first step in designing an energy research and development program.

Energy policies other than research and development will also be required if the energy future is to evolve in the desired direction. Some energy policy decisions will be necessary to support research and development. Other decisions will be needed to foster the application of new technologies after commercial feasibility has been demonstrated. Still other policies aimed at goals outside the energy system will influence both the execution of the research and development program and the implementation of new technologies derived from it.

SUPPORTING PROGRAMS

The evolution of the energy system will be heavily influenced by policies not directly aimed at energy questions, e.g., environmental effects, basic research, and manpower development policies. Because of their close relationship to energy, specific programs in these areas are recommended for levels of **incremental** funding in addition to the $10 billion energy research and development program. The recommended increments to these supporting programs are considered the **minimums** required to guarantee both the successful conduct of the proposed energy research and development and the rapid implementation of its results throughout the energy system.

OTHER POLICY ACTIONS

Because energy plays such a central role in our society, a number of policy actions on nonenergy goals will affect the energy system. Some areas where policy actions affect the energy system are rate regulation, price controls, antitrust and patent laws, land-use laws, and leasing of public lands.

Because decisions on these policies involve a wide range of considerations outside energy matters, this report refers only to their implications and merely suggests directions that will facilitate energy research and development and help realize its benefits.

SYNOPSIS

Chapter 2 summarizes the recommended five-year $10 billion Federal program, details of which are in Appendix A, and presents the recommended Fiscal Year 1975 budget, the first increment of the recommended program.

Chapter 3 summarizes the energy supply and demand situation and indicates how much change is needed to regain self-sufficiency.

Chapter 4 sets out the five major tasks required to regain and maintain energy self-sufficiency and from these tasks derives the goal of the Nation's energy research and development program.

Chapter 5 discusses the role of the Federal Government in energy research and development, including its relations with industry, its own

research and development strategy, criteria for funding of Federal programs, and guidelines for managing the Federal effort.

Chapter 6 explains the technological obstacles to accomplishing the five tasks and discusses the major constraints under which the research and development program must be carried out.

Chapter 7 classifies the research and development objectives under each of the five tasks into short-, medium-, and long-term categories.

2

The Recommended Five-Year National Energy Research and Development Program

Table 2-1 summarizes the recommended five-year research and development program. This program, properly executed, can reasonably be expected to attain the objectives set out in Chapter 7. The salient features of the program are:

- A reasonable balance among the tasks required to regain and maintain energy self-sufficiency:

Task 1.	Conserve energy and energy resources	22%
Task 2.	Increase domestic production of oil and gas	22%
Task 3.	Substitute coal for oil and gas	23%
Task 4.	Validate the nuclear option	24%
Task 5.	Exploit renewable resources (solar, geothermal, fusion, hydroelectric)	9%
		100%

- Massive concentration of effort on short-term objectives: 70% of the total program and 45% of the Federal program go to short-term goals.

- A prudent level of effort directed toward mid-term goals: 23% of the total program and 39% of the Federal program.

- A small but significant share of the program aimed at long-term goals: 7% of the total program, all Federal.

- A conservative estimate of the private research and development contribution that could be forthcoming in response to vigorous and imaginative Federal leadership. (Estimates are based on the 1971 data from the Ford Foundation Energy Policy Project for research and development in the oil, gas, coal-mining, electrical, and electrical supplier industries [$1400 million/year] plus data on

Table 2-1.—RECOMMENDED NATIONAL ENERGY RESEARCH AND DEVELOPMENT PROGRAM, FY 1975-1979

Self-Sufficiency Task	($ Millions) Short-Term Objectives	Mid-Term Objectives	Long-Term Objectives	Total
1. Conserve Energy and Energy Resources				
Federal	1,160	280		1,440
Private	3,200	300		3,500
Subtotal	4,360	580		4,940
2. Increase Domestic Production of Oil and Gas				
Federal	430	30		460
Private	4,300	200		4,500
Subtotal	4,730	230		4,960
3. Substitue Coal for Oil and Gas on a Massive Scale				
Federal	1,690	485		2,175
Private	2,500	500		3,000
Subtotal	4,190	985		5,175
4. Validate the Nuclear Option				
Federal	1,100	2,990		4,090
Private	1,000	250		1,250
Subtotal	2,100	3,240		5,340
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible				
Federal	135	150	1,550	1,835
Private	220	30		250
Subtotal	355	180	1,550	2,085
TOTAL				
Federal	4,515	3,935	1,550	10,000
Private	11,220	1,280		12,500
GRAND TOTAL	15,735	5,215	1,550	22,500

Supporting Programs (incremental Federal funding to present programs)	
Environmental Effects	650
Basic Research	300
Manpower Development	50
	1,000

research expenditures of the automobile industry provided in Congressional hearings [$200 million/year] adjusted for inflationary increases since 1971 and increased expenditures in response to already recognized shortages, making a total of some $2000 million/year in FY 1974. Industry can reasonably be expected to increase research and development spending by at least 25% above current estimates in response to the more than doubled Federal contribution, properly structured Federal policies, and the incentives of higher prices.)

- Allocation of Federal funds among tasks based on the total requirements of each task and on the contributions expected from industry; the Federal share of the total effort varies from slightly under 10% for Task 2 to 88% for Task 5.

- Recommendation of $1000 million for increases in research and development funding of ongoing Federal programs that support energy research and development and energy production.

CONTRIBUTION TO SELF-SUFFICIENCY

Table 2-2 shows the estimated contribution of the recommended program to the goal of regaining self-sufficiency. Entries for 1972 display the composition of energy inputs for that year, including imports of 5.1 million barrels/day of oil equivalent (mostly oil and some natural gas). The Total Energy entries for 1980 and 1985 are based on a projected annual rate of growth in energy consumption of 4.1% from 1972 to 1980 and 3.9% from 1980 to 1985. The conservation entries show the energy savings expected to result from the recommended research and development program. Fuel-source entries for 1980 and 1985 show:

- Contributions expected with programs underway before the President's June 29, 1973, energy initiatives (first column).

- The extra contribution expected from the accelerated research and development efforts included in these initiatives (second column).

- The total contributions expected with the $10 billion program recommended in this report (third column).

The data support the following conclusions:

- Self-sufficiency may be attained by 1985 with the expected payoff of the proposed research and development program. By then, the proposed program should yield the equivalent of:
  (1) 7.0 million barrels/day of energy savings from conservation efforts, and
  (2) 9.0 million barrels/day of increased domestic production.

Table 2-2.—ESTIMATED CONTRIBUTION TO ENERGY INPUTS
(Million Barrels/Day Oil Equivalent)

Energy Source	1972 Actual Inputs	1980 Total with Former Program[1]	1980 Increment from Recommended Program[2]	1980 Total with Recommended Program	1985 Total with Former Program[1]	1985 Increment from Recommended Program[2]	1985 Total with Recommended Programs
Total Energy	34.1	47.0		47.0	57.0		57.0
1. Conservation	—	—	4.7	(4.7)	—	7.0	(7.0)
Production Requirements	34.1	47.0		42.3	57.0		50.0
2. Domestic Production of Oil and Gas	21.4	21.5	0.5	22.0	21.5	5.1	26.6
3. Domestic Coal Production and Conversion	5.9	9.1	0.5	9.6	11.4	2.5	13.9
4. Nuclear	0.3	3.6	0.2	3.8	7.1	0.6	7.7
5. Renewable Resources (Solar, Geothermal, Hydroelectric)	1.4	0.8	0.2	1.0	1.0	0.8	1.8
Imports	5.1	12.0	(6.1)	5.9	16.0	(16.0)	0.0

[1] Contributions expected from policies in effect prior to the President's June 29,1973, energy initiatives, including the energy research and development program contemplated before that initiative. See Appendix B for a comparison of the formerly contemplated program and the program recommended in this report.

[2] See Appendix B for explanation of the methodology used to derive these values.

- By 1980 the recommended program will have decreased the demand for imports by half, to 5.9 million barrels/day of oil equivalent.

- To replace by 1980 the other half of the demand for imports, the Nation must, in addition to conducting the accelerated research and development program:
  (1) reduce energy use by imposing administrative restrictions on consumption, and/or
  (2) take extraordinary measures to stimulate a sharp increase in domestic production.

STRATEGY FOR PROGRAM EXECUTION

The major elements of the strategic approach embodied in the proposed program are:

- Proceed immediately and simultaneously with work on all promising conservation and supply technologies.

- Within each technology, concentrate major effort on the most promising technical approach and keep back-up options advancing at a reasonable pace.

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- Pursue most individual research efforts in an accelerated but orderly manner, avoiding the risks of "great leaps forward" that do not materialize; seek, instead, sustained progress toward established objectives.

- Take high risks in a few technologies having very high potential payoffs (e.g., in situ coal gasification and shale retorting and massive fracturing of tight formations containing gas).

- Employ the principle of redundancy: conduct enough parallel efforts to be able to afford failure in some and still attain overall objectives.

- Move toward the capability for self-sufficiency by laying the essential groundwork for a production program based on improved technologies.

A MODEL FOR INTEGRATING RESEARCH AND DEVELOPMENT AND PRODUCTION EFFORTS

One major departure from the conventional approach to research and development is proposed: a Synthetic Fuels Pioneer Program. This effort would begin construction in FY 1975 of a number of commercial-scale plants using existing technologies to produce commercial quantities of synthetic fuels from coal. Program objectives are to:

- Demonstrate the Nation's determination to regain and maintain energy self-sufficiency through an action program that produces commercial quantities of synthetic fuels.

- Lay the technical, engineering, and production groundwork required to support rapid acceleration of synthetic-fuel domestic production if required.

- Adapt proven technologies for synthetic-fuel production to United States conditions.

- Identify by experience the nature and magnitude of the technical, environmental, and economic problems that require priority research and development attention.

- Assign hand-picked teams of scientists, engineers, and technicians to break major bottlenecks to increased productivity and to learn to control and treat adverse environmental effects.

- Establish, based on sustained full-scale operation, technical, engineering, and economic benchmarks for evaluating improvements that result from research and development programs.

- Provide a bridge between the research and development community and the production sector that will facilitate the exchange of

information, ideas, and experience gained under full-scale operational conditions.

Major features of the program would be that:

- Federal guarantees of prices or loans under the Defense Production Act or such other authority as may be appropriate would ensure the commercial viability of the plants.
- Exceptions to normal permit requirements would be granted under the authority of emergency energy legislation.
- Defense Production Act or other authority would be used to allocate materials and components on a priority basis to begin construction of these plants in FY 1975 with the objective of having them in full production by the end of FY 1976.
- Plants would be built, owned, and operated by private commercial concerns or consortia; no major Federal construction monies would be required.
- Federal research and development funds in the amount of $355 million would be earmarked for extra construction costs incurred for modifications required to support experimental testing of advanced design components ($200 million) and for research operations ($155 million).
- There would be wide dissemination of the engineering, production, economic, safety, environmental, and other data acquired from operating the plants.
- Plants would be available to the Government for experimentation and evaluation of new techniques, materials, and components on the basis of cost reimbursement to the operator.
- Necessary measures would be taken to contain any adverse environmental impacts within the immediate locale of the plants; this action would provide an ideal experimental base for research into methods of environmental protection and restoration. Industry would bear the costs of containment, and Government would share research costs with industry.

Compared to the total national requirement, the actual production impact of the Synthetic Fuels Pioneer Program would be modest. Its chief benefits would be the knowledge and experience gained that would provide a credible capability for rapid expansion of production if required. This would provide for better integration of the research and development and production programs.

Examples of the kinds of plants that could be included in the program are:

- Pipeline-quality (high-BTU) gas plants using the Lurgi process
- Low-BTU gas plants using the Koppers-Totzek process

- Solvent-refined-coal plants
- Oil from shale plants
- Methanol plant
- Plants to produce hydrogen, ammonia, olefins, diolefins, aromatics, and other petrochemicals.

Details of program implementation remain to be worked out, but discussions with industry representatives indicate that the proposed program could expect an enthusiastic reception from industry. It is strongly recommended as an action program that promises increased production, increased knowledge, and an increasingly realistic and productive interaction between Government and industry based on hard facts derived from commercial-scale operations.

RECOMMENDED FY 1975 BUDGET

Table 2-3 summarizes the FY 1975 Federal budget recommendations by task and displays for comparison purposes corresponding Federal obligations made in FY 1973 and planned for FY 1974. Several features of the program are evident in Table 2-3.

Table 2-3.–FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY MAJOR PROGRAM ELEMENT, FY 1973-1975

	($ Millions)			Percent
Self-Sufficiency Task	Actual FY 73	Planned FY 74	Recommended FY 75	Increase FY 73-75
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	215%
2. Increase Domestic Production of Oil and Gas	20.0	19.5	51.7	159%
3. Substitue Coal for Oil and Gas on a Massive Scale	88.8	167.2	405.0	356%
4. Validate the Nuclear Option ...	395.8	517.3	731.7	85%
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123.0	217.5	162%
TOTAL	640.2	889.3	1,572.1	146%

- A very substantial acceleration of the upward trend (begun in FY 1974) of Federal energy research and development obligations is proposed. Annual Federal research and development funding would more than double over FY 1973 and would increase by more than three quarters (77%) over FY 1974.

- The largest percentage increase (356%) would be devoted to the use of coal, the Nation's most plentiful energy resource.

- Energy conservation and efforts to use renewable resources would receive major increases.

- The funding increase recommended for oil and gas production reflects the vigorous private research and development programs in that industry and the advanced state of technology that has resulted. Recommended Federal efforts are intended as supplements to selected key areas, including resource assessment, needed to round out an ongoing private program.

- The fission power program would receive a modest increase, much of it aimed at speeding up the availability of electricity from nuclear power plants. This reflects in part the generous level of funding for the nuclear program over past years compared to other programs.

NEED FOR CONTINUING PROGRAM REVIEW

One crucial point deserves emphasis. The FY 1975 budget recommendations are presented with high confidence that they are the right first step in the five-year program. The five-year funding levels are presented with confidence that they represent a sound plan based on what is now known for the five-year period. The actual five-year obligations will be different from those recommended here because the rate at which progress will occur in each program element is unforeseeable.

The entire program should be evaluated at least annually and funds reallocated among surviving programs. If circumstances justify, the $10 billion, *which now appears sufficient*, should be expended earlier than planned, and the total cost of the five-year program should be increased to fund essential research and development. In no case should the planning figures for the later years of the proposed program, or even the total program figures, be either a floor or a ceiling on program funding. Rather, each program should be funded on its merits, accelerated when it succeeds, and terminated or cut back severely when it fails after a reasonable amount of effort. These determinations should be made as part of a total program review, not on a project-by-project basis.

SUMMARY OF FEDERAL PROGRAM ELEMENTS

The following sections contain summaries of the work planned in the principal program elements of each self-sufficiency task. A more detailed budget display for the Federal Energy Research and Development Program is presented in Table 2-4, and subprograms are explained in Appendix A. The major subprograms and funding levels are summarized below in accord with the five major tasks and their short-term, mid-term, and long-term objectives. Tables 2-5 through 2-10, found at the end of the descriptive material,

provide summaries for each Fiscal year, FY 1975 through FY 1979, and for the total program of total obligations, operating expenses, equipment obligations, and construction obligations.

Table 2-4.—FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY INDIVIDUAL PROGRAM ELEMENT, FY 1973-1979

Self-Sufficiency Task	($ Millions) Actual FY 73	Planned FY 74	Recommended FY 75	Recommended FY 75-79 Program
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	1,440
Reduced Consumption	12.1	22.3	29.9	210
Increased Efficiency	40.7	40.0	136.3	1,230
2. Increase Domestic Production of Oil and Gas	20.0	19.5	51.7	460
Production	12.8	11.2	31.7	310
Resource Assessment	7.2	8.3	20.0	150
3. Substitute Coal for Oil and Gas on a Massive Scale	88.8	167.2	405	2,175
Mining			45	325
Direct Combustion			30	200
Synthetic Fuels			240	1,270
Common Technology			90	380
4. Validate the Nuclear Option	395.8	517.3	731.7	4,090
Safety, Enrichment, HTGR, and Other	129.7	151.7	216.2	1,245.7
Breeder	266.1	365.6	515.5	2,844.3
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123	217.5	1,835
Fusion	74.8	98.7	145.0	1,450
Solar	4.2	13.2	32.5	200
Geothermal	3.8	11.1	40.0	185
TOTAL	640.2	889.3	1,572.1	10,000
Supporting Programs (incremental Federal funding to present programs)				
Environmental Effect			105.9	650
Basic Research			43.0	300
Manpower Development			5.0	50
			$153.9	$1,000

	($ Millions) FY 75	FY 75-79
Task 1. Conserve Energy and Energy Sources	**$166.2**	**1440.0**
A. Reduced Consumption	**29.9**	**210.0**
1. End-Use Consumption	**19.9**	**150.0**

Major studies will be conducted to determine energy use patterns in building conditioning, industrial processes, transportation systems, integrated utility systems, and patterns across energy sectors. Information gained should provide opportunities for initiating or developing energy-conserving designs, construction, and operating practices.

2. Improved Management	**10.0**	**60.0**

A vigorous effort will be launched to coordinate the activities of the many government departments and agencies that have been compiling data pertaining to the U.S. energy system. Existing systems models will be improved or new models developed, and the data base will be greatly enlarged and kept current. The systems approach and models will be used to assess new technologies and to provide quantitative analysis of alternative energy policies, energy research and development strategies, and energy system configurations.

B. Improved Efficiency	**136.3**	**1230.0**
1. High-Temperature Gas Turbine	**18.3**	**315.0**

In conjunction with conventional steam turbines, combined cycles can be formed that produce greater thermal efficiencies than the steam turbine cycle alone. An open-cycle high-temperature gas turbine will be built to operate in a 100-MW(e) combined-cycle demonstration power plant by 1979. A 2- to 3- MW(e) power plant demonstration unit will be used to assess space heating from power plant waste heat; if successful, the Department of Housing and Urban Development will use such units in model energy-conserving housing developments. A special helium direct-cycle gas turbine facility will be built to develop turbines for use with the high-temperature gas-cooled nuclear reactor.

2. Advanced Cycles, Fuel Cells, and Other Concepts .	**18.0**	**210.0**

Potassium vapor and magnetohydrodynamic "topping" cycles can also form combined cycles for steam turbines. A 30-MW(e) potassium vapor topping unit will be built and operated by 1979 as a pilot plant. Fuel cells of considerable variety will be assessed in

pilot plants. The use of wastes as fuels and basic generator research for magnetohydrodynamics are included in this program.

	($ Millions)	
	FY 75	FY 75-79
3. Advanced Auto Propulsion	53.0	300.0

Advances in fuel economy and reductions in pollutant emissions using feasible state-of-the-art technologies will be sought and demonstrated for automotive engines. Results will serve to define regulatory standards. Several propulsion and vehicle systems will be evaluated, two of which will be brought to the engineering development phase. Prototype batteries, motors, controls, and power conditioning equipment will be demonstrated by FY 79. Nonpetroleum energy sources will be investigated.

4. Rail, Bus, Ship, and Air	20.0	205.0

Two major demonstrations are planned to evaluate integrated bus transit systems in large cities. Intermodal transfer of freight from truck to rail will be investigated. New aircraft and ship designs with low drag characteristics will be evaluated and the feasibility of nuclear-powered commercial ships will be examined.

5. Energy and Fuel Transportation and Storage	27.0	200.0

A joint government-industry development program is expected to produce prototype demonstration projects for 1100-kV a-c overhead transmission systems and a 100-MW d-c terminal system by 1979. Four improved types of underground cables will be developed for commercial use in that period. Battery development will continue, with emphasis on the sodium-sulfur and lithium-sulfur designs. A 10-MW pilot model of the more promising design will be built for testing at practical storage levels. The concepts of storing energy in a superconducting magnet or a flywheel will be examined to the point of engineering development. Advanced marine transportation systems will be explored to increase availability and distribution of domestic fuel sources.

The savings in oil equivalent that can be expected from attainment of the objectives of the program in Task 1 are 4.7 million barrels/day of oil by 1980 and 7.0 by 1985.

Task 2. Increase Production of Oil and Gas .... (including resource assessment)	**$51.7**	**$460.0**
A. Resource Assessment	20.0	150.0

New and improved techniques and equipment will be developed and tested to aid the assessment of potentially discoverable resources of fossil and nuclear fuels and supporting elements; to promote their discovery and conversion to reserves; and to determine the quality and

usable quantity of coal, oil shale, and tar sands. Data will guide Federal leasing policy and stimulate accelerated exploration by industry.

	($ Millions) FY 75	FY 75-79
B. Secondary and Tertiary Recovery	10.7	70.4

In a joint program with industry, 15 types of reservoirs will be tested with combinations of four methods for secondary and tertiary recovery of residual reserves. Twenty separate experiments will be conducted. Analysis of results is expected to determine economic feasibility for a variety of particular reservoir types.

C. Stimulation of Low Permeability Formations	9.1	96.3

Fluid or hydrofracturing and chemical-explosive fracturing techniques will be tested on a scale not previously tried in an attempt to stimulate low-permeability gas reservoirs that cannot be economically tapped using conventional completion techniques. Seven experiments are planned in three different reservoirs. One further nuclear stimulation demonstration is planned. The program is designed to determine which stimulation technique or combination is most suitable for particular reservoir characteristics.

D. Advanced Drilling	2.6	15.5

Development will be continued on jet drilling techniques and equipment and spark cavitation drilling concepts to increase deep drilling rates. Development of reliable downhole power supplies of up to 100 hp will be pursued. Blowout control and oil-spill cleaning methods will be assessed and improved.

E. Oil-Shale Processing	9.3	127.8

In situ retorting of oil shale will be tested in the Rocky Mountains, using a combination of several different fracturing techniques and retorting conditions. The recovery rates for each combination and the control problems encountered will be analyzed to determine optimal technical design.

The attainment of the objectives of the programs under Task 2 will guarantee the previously projected supply, equivalent to 21.5 million barrels/day of oil, and contribute an additional supply, equivalent to 0.5 million barrels/day by 1980 and 5.1 million barrels/day by 1985.

Task 3. Substitute Coal for Oil and Gas	$405.0	$2175.0
A. Mining	45.0	325.0

New and improved techniques for surface and underground coal and oil-shale mining that would increase productivity and recovery rates and at the same time meet environmental and health standards will be

developed and tested in demonstration mines. Integrated mining reclamation methods will be applied to acid Eastern and arid Western surface-mined areas to find optimum techniques for each region.

	($ Millions) FY 75	FY 75-79
B. Direct Combustion	30.0	200.0

Pilot, demonstration-scale, and module plants having a pressurized fluid-bed combustion system will be constructed. A companion effort through the demonstration scale will be conducted in atmospheric fluid-bed systems. Combustion modifications will be made in conventional coal- and oil-burning boilers and furnaces to improve the efficiency of combustion under environmentally acceptable conditions.

C. Synthetic Fuels	240.0	1270.0
1. High-BTU Gasification	35.0	340.0

Four pilot plants for testing advanced technologies will be built. The best features will be incorporated into a demonstration plant by 1979. Knowledge gained from building and operating plants with existing technologies, under the Synthetic Fuels Pioneer Program, should stimulate progress in this area.

2. Coal Liquefaction	75.0	375.0

Three pilot plants to test advanced processes for coal liquefaction will be constructed, and a design for a major demonstration plant is expected by 1979.

3. Low-BTU Gasification	30.0	200.0

Entrained-bed and fluidized-bed methods for gasifying coal will be tested through demonstration-plant operation in a joint government-industry program of research and development. Three to five other promising approaches to gasification will be tested on a pilot scale.

4. Synthetic Fuels Pioneer Program	100.0	355.0

This aggressive new program will immediately begin construction of full-scale commercial plants using existing technologies for producing synthetic fuels from coal. The Lurgi gasification technique and the Fischer-Tropsch liquefaction method will be employed, and a combined process for methanol production will be included. Funding will be derived almost exclusively from private industry, with guaranteed prices or loans as incentives. These will be provided under the Defense Production Act or other authority. Federal research and development funds will be added for investigating processes, testing modifications that appear promising, and disseminating findings. Benchmarks will be

established for engineering performance, economic parameters, and environmental aspects of commercial operations. This ambitious production program is expected to accelerate specific research and development efforts related directly to commercial-scale operations and to speed up the implementation of new advances.

	($ Millions) FY 75	FY 75-79
D. Common Technology	90.0	380.0
1. Environmental Control Technology	70.0	260.0

Program emphasis is on the development of advanced flue-gas desulfurization processes that reduce requirements for sludge handling and control and recover elemental sulfur. A major effort will be made to complete and operate several lime/limestone pilot units attached to coal-fired electric generating plants.

The relatively new program directed toward identifying and controlling fine-particulate emissions will be accelerated. Approximately half the funding will be directed to the construction of pilot and demonstration units and instrumentation required to assess the dimensions of this problem and the success of tested processes.

Chemical and mechanical cleaning processes applied to raw coal are expected to remove up to half the organic sulfur. The TRW Meyers process seems promising for such cleaning and will be tested.

Fuel-conversion process-control research and development efforts will identify trace-element emissions that are expected to be present in significant quantities when large volumes of coal are processed. Little is known about their characteristics and control. The program will determine the pollutant effluents and their rates of release and develop processes for control so that the technology can be applied in early commercial-scale plants.

Residues from coal processing will create massive disposal problems that could impact heavily on the environment. Methods for treating, revegetating, or otherwise mitigating harmful or undesirable effects will be sought. In situ coal gasification will be examined as a means of reducing environmental problems.

2. Supporting Research and Development	20.0	120.0

Essential and urgent efforts in developing fittings, pipes, and other hardware; enhancing supplies of hydrogen; and characterizing materials are required to support the main programs in coal research. Coal conversion processes will operate at high temperatures, contain corrosive and abrasive materials, and may include high pressures. To be economic, the processes must run for long periods without overhaul or replacement of major parts. Materials and components that can survive under such conditions

must be engineered and tested. In many cases, basic metallurgy problems must be solved. Undoubtedly, new problems will be identified through operation of pilot and demonstration plants and the commercial-scale plants in the Synthetic Fuels Pioneer Program. Hydrogen used in coal conversion processes to enrich the BTU content of the products is produced from the coal or from process water. Current methods are costly or use large quantities of feed stock. Theoretical and empirical efforts will be needed to develop better catalytic methods to produce hydrogen from water.

The attainment of the objectives of the programs under Task 3 will guarantee the previously projected supply, equivalent to 9.1 million barrels/day of oil, and contribute an additional supply equivalent to 0.5 million barrels/day by 1980. By 1985 the projected supply of 11.4 million barrels/day of oil will be increased by 2.5 million barrels/day.

	($ Millions)	
	FY75	FY75-79
Task 4. Validate the Nuclear Option	**$731.7**	**$4090.0**
A. Safety, Enrichment, HTGR, Other	**216.2**	**1245.7**
1. Safety—Reactors and Fuel Handling	**90.6**	**719.2**

Theoretical and experimental investigations will be conducted to determine component failure and accident probabilities for nuclear reactors. Practical results derived from the Loss of Fluid Test Facility (LOFT) will yield data necessary for the design and engineering of safety features and the establishment of regulatory standards.

An engineered waste-storage facility will be constructed, and a pilot facility in bedded salt will be developed to assess the disposal of long-lived radioactive wastes in geologic formations. Ancillary solidification processes will be tested. Methods for elimination of krypton, tritium, and transuranic components of reactor and reprocessing effluents will be tested.

A dry cooling tower to replace liquid cooling will be investigated in Wyoming in a joint government-industry venture. Standardized criteria for nuclear reactor siting will result from an in-depth assessment of the relationship between site characteristics and construction and operating experience, hopefully expediting future installations.

2. Uranium Enrichment	**64.2**	**294.2**

The search for more-efficient uranium enrichment processes will include development aimed at improving the gaseous diffusion process, demonstrating the commercial feasibility of the gas centrifuge method, and exploring the technical feasibility of isotope separation using lasers. The centrifuge test facility and ancillary facilities will be completed.

		($ Millions) FY 75	FY 75-79
3.	**High-Temperature Gas Reactor (HTGR)**	40.0	163.8

The base program for the HTGR will continue the development of components and will review safety features. Reprocessing and refabrication pilot plants will be built to complete needed research and development on the ^{233}U-thorium cycle. This work will enlarge the potential fuel supply by adding the abundant element thorium to uranium as a reactor fuel.

4.	**Light Water Self-Sustaining Reactor**	21.4	68.5

An experimental core for this reactor will be tested in the Shippingport facility. Success of this concept will offer a way to make the light-water reactor fuel cycle self-sustaining through conversion to the ^{233}U-thorium cycle.

B.	**Breeders**	515.5	2844.3
1.	**Liquid Metal Fast Breeder Reactor (LMFBR)** ...	477.0	2556.6

A comprehensive LMFBR technology effort includes support of the Fast Flux Test Facility and support of a 300-MW(e) LMFBR demonstration power plant scheduled for operation in 1980 as a joint government-industry venture. The LMFBR base program includes continued development of fuels and studies of their behavior under different conditions. Engineering and safety aspects will be analyzed at a variety of specialized facilities. These include an advanced fuels laboratory, a steam-generator test facility, a safety test facility, and a transient safety test facility. The suitability of various methods for handling and transporting plutonium will be assessed to generate appropriate standards.

2.	**Gas Cooled Fast Reactor (GCFR)**	17.0	140.0

The program for the GCFR will provide required technology on fuel and reactor-core development, physics, and safety. A low level of effort will also be expended on the molten-salt breeder program.

3.	**Advanced Technology**	21.5	147.7

This work is planned to develop new breeder fuel and materials that can increase breeding ratios and power ratings and decrease the conservatism presently required in breeder designs. Neutron cross-section information needed for the design of fast reactors will be developed.

The attainment of the objectives of the programs under Task 4 will guarantee the previously projected supply equivalent to 3.6 million barrels/day of oil, and contribute an additional supply equivalent to 0.2 million barrels/day by 1980. By 1985 these programs will guarantee the

previously projected supply of 7.1 million barrels/day of oil equivalent and add 0.6 million barrels/day of oil equivalent.

	($ Millions) FY 75	FY 75-79
Task 5. Exploit Renewable Energy Sources	**$217.5**	**$1835.0**
A. Fusion	**145.0**	**1450.0**
1. Magnetic Confinement	**135.0**	**1340.0**

Recent successes in fusion-related experiments confirm that the program should move to the next level of orderly experimental development. Computer-analyzed theoretical studies of fusion-relevant plasmas in various confinement configurations will be performed to understand the equilibrium, stability, and transport properties of the plasmas. Facilities will be constructed to test plasma shapes, neutral-beam heating, scaling, and improved confinement. Fusion plasmas create neutron, neutral, charged-particle, and photon environments that have adverse effects on most materials. Basic and applied research will be directed at finding compatible materials that can be fabricated for use in fusion reactors.

2. Laser Fusion	**10.0**	**110.0**

This subprogram will extend the theoretical base established in the military-oriented laser fusion program. An experimental demonstration of significant thermonuclear burn and of scientific break-even for the method is scheduled.

B. Solar	**32.5**	**200.0**
1. Heating and Cooling of Buildings	**12.8**	**50.0**

Solar heating and cooling of buildings is entering the pilot-plant stage. Applicability studies, design-criteria development, and component testing will be conducted on a much enlarged scale. Operating pilot systems will be installed in single-family and multifamily dwellings, in agricultural buildings, and in commercial and industrial buildings. This effort could provide the basis for an industry prepared to manufacture solar-energy heating and cooling systems in large quantities. Component development is expected to increase reliability and decrease costs.

2. Solar Thermal Conversion	**5.0**	**35.5**

Major emphasis in this subprogram will be placed on the research and development of key subsystems for the optical-transmission central-receiver tower approach. Three system-design efforts will be conducted in parallel. Design, hardware procurement and integration, and testing of a 10-MW(e) pilot plant will be achieved.

	($ Millions) FY 75	FY 75-79
3. **Wind Energy Conversion**	6.2	31.7

A series of experimental wind generator systems in increasing size and performance capability will be constructed and tested. Multi-unit wind generator systems making up a wind "farm" up to 10 MW(e) will be built late in the program period.

4. **Ocean Thermal Conversion**	1.9	26.6

Emphasis will be placed on design, production, and testing of system components. Key elements that will require significant adaptation of existing technology include the heat exchanger, deep-water pipe, and overall plant structural design.

5. **Photovoltaic Conversion**	4.2	35.8

The photovoltaic program will concentrate on the single-crystal silicon approach, with a modest effort on alternative materials and concepts. Major improvements in materials and processes are needed to permit automated production of cells and to accomplish significant cost reductions.

6. **Bioconversion**	2.4	20.4

The construction and operation of two small-scale pilot plants involves the conversion of wastes into methane and clean fuels. Later in the program period a 10-ton/day urban waste pilot plant will be constructed. Laboratory-scale studies of methods for converting various organic materials, particularly including biomass production, will also be studied.

C. **Geothermal**	40.0	185.0
1. **Resource Assessment and Exploration**	9.7	49.2

Activities include the development and field use of new and improved geophysical, geochemical, geologic, and hydrologic instrumentation and techniques to locate and evaluate geothermal resources. Improved prospecting and evaluation methods should allow more confident prediction of the energy potential of individual wells and entire fields. Assurance that a significant (20 to 30 year) supply of geothermal energy is available for plant operation is essential in inducing potential users to invest in power plant development.

2. **Environmental, Legal, and Institutional Research** ..	3.4	10.9

The effects of potential earth-tremor effects that might result if geothermal resources are extracted will be analyzed. Recirculation methods may maintain in situ conditions and obviate such

problems. Minerals, salts, and noxious gases may be prominent by-products of the extraction procedures and must be monitored and eliminated. Technology transfer will be encouraged by cooperative arrangements with industry, and special attention will be given to the institutional, legal, social, and environmental issues bearing on utilization of these novel sources of energy.

	($ Millions) FY 75	FY 75-79
3. **Resource Utilization**	16.9	78.6

Several different types of geothermal resources will be examined: high-temperature low-salinity and high-salinity convective wells, geopressurized sedimentary systems, low-temperature convective wells, hot dry rock, and normal geothermal gradients. Four different demonstration plants will be completed and a fifth plant will be started. Each type of resource poses special problems in location and distribution, reservoir analysis, environmental hazards, energy conversion and utilization, and severity and solution time of technical questions involved in bringing the resource to on-line production. Each experimental facility, therefore, will serve as a flexible test bed for research and engineering development, as well as for demonstrations of electrical generation and other uses of geothermal heat. Technology transfer will be encouraged by cooperative arrangements with industry.

4. **Advanced Research and Technology**	10.0	46.3

Major technical problems to be solved are concerned with drilling in hostile geothermal environments, methods of well completion, materials and equipment for extracting corrosive fluids, monitoring and controlling emissions and wastes, and developing practical binary cycles that use low-temperature working fluids.

The attainment of the objectives of the programs under Task 5 will guarantee the previously projected supply, equivalent to 0.8 million barrels/day of oil, and contribute an **additional** supply equivalent to 0.2 million barrels/day by 1980. By 1985 it will guarantee the previously projected supply of 1.0 million barrels/day and add 0.8 million barrels/day of oil equivalent.

SUPPORTING PROGRAMS (Incremental Funding)	**$153.8**	**$1000.0**
A. Environment	**105.8**	**650.0**

These programs aim to provide a sound scientific and technical basis for ensuring that potential environmental and health insults will be recognized and effectively controlled as policies to regain and maintain self-sufficiency are implemented.

1. **Pollutant Characterization, Measurement, and Monitoring**	13.3	96.3

The chemical and physical characteristics of by-products associated with each phase of existing and new energy systems from extraction through utilization of the energy will be identified. Methods will be improved or developed for measuring and monitoring ambient and source levels of airborne sulfur oxides, fine particulates, sulfates, krypton, strontium, tritium, waterborne nitrates, and cyanides released by energy systems.

	($ Millions) FY 75	FY 75-79
2. Environmental Transport Processes	20.5	110.0

Field studies will be conducted to determine the relationships between emissions of thermal, chemical, and radioactive pollutants and the resulting environmental concentrations by accounting for the pathways of these substances from the energy-system emitter to ultimate fate in the atmosphere or in fresh or marine waters.

3. Effects: Health, Ecological, Welfare, and Social ..	69.1	413.7

These studies are intended to strengthen the scientific basis for existing and new air and water quality standards, to define the effects of simultaneous exposure to number of pollutants, and to determine long-term low-level effects of fossil-fuel and radioactive pollutants. Ecological research will assess the impact of coal, oil shale, uranium, and geothermal extraction techniques; of emissions released from energy conversion and reprocessing plants; of waste-heat release and antifouling additives; and of entrainment and impingement in cooling systems. The effects of environmental pollution on the general social welfare will be investigated in studies of public attitudes and values and in physical analyses of artistic works and building materials.

4. Environmental Assessment and Policy Formulation	3.0	30.9

Mechanisms will be developed to evaluate the institutional, economic, sociological, and technical implications of environmental impacts and controls and to calculate cost-benefit relationships. Such analyses of alternative energy systems and research and development proposals should permit rational integration of environmental considerations into the energy-policy decision-making process.

B. Basic Research	43.0	300.0

These programs are designed to explore phenomena, processes, and techniques in physical, chemical, biological, environmental, and social sciences affecting energy to ensure the development of new basic knowledge. Discoveries of new concepts may revolutionize energy production and utilization.

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		($ Millions) FY 75	FY 75-79
1.	**Materials**	**8.0**	**55.0**

This work is directed toward understanding the reactions of materials subjected to high temperature, thermal shock, radiation in various forms, and corrosives. Super-conducting materials for very long distance electrical transmission, ion conductance phenomena, and properties of ceramic materials will be investigated.

2.	**Chemical, Physical Engineering**	**16.0**	**110.0**

The production of hydrogen and hydrocarbons by thermochemical, photochemical, and biochemical processes from nonfossil sources including water will be stressed. Efforts will be supported to gain understanding of hydrogen storage systems, principally hydrides; of catalysis and the roles of surfaces; of kinetic and heat-transfer processes that affect combustion efficiences; of thermodynamic properties of reactants and carriers important in the energy system; of atmospheric and oceanic mixing; of separation processes; and of methods for detecting the distribution of trace elements and pollutants.

3.	**Biological**	**12.0**	**80.0**

Basic knowledge will be acquired to convert organic wastes to usable fuels and to detoxify energy-related wastes. Hydrology and climatology, ecosystem interactions, and environmental geology will receive attention.

4.	**Plasmas**	**3.0**	**20.0**

Fundamental research into plasmas and their response to electromagnetic fields and radiation will aid in the development of direct energy conversion systems, orbital solar stations, colliding-beam fusion reactions, and the potential use of kinetic and rotational energies of ocean and planetary movements. Plasma physics is essential, of course, to the entire fusion program.

5.	**Mathematical and Social**	**4.0**	**35.0**

Modeling of the entire energy system will require mathematical and computer techniques to handle large and complex technical and socioeconomic data bases in order to understand the effect of technological developments and policy decisions on the energy system. To better understand future energy requirements, social and psychological responses of people, including motivational studies, and national attitude analyses may be helpful. Finally, analysis of the effects of national regulatory policies and international relations on the dynamics of both energy research and development and production will require novel methodologies.

Table 2-5.—SUMMARY SCHEDULE OF FEDERAL ENER[illegible] [illegible]SEARCH AND DEVELOPMENT PROGRAMS, FY 197[illegible]-197[illegible]
($ Millions)

Self-Sufficiency Task			FY 75-79 Energy Research a[illegible]ams						FY 75-79 Agency Projections
	FY 73	FY 74	FY 75	FY 76	FY 77	FY 78	FY 79	FY [illegible]	
1. Conserve Energy and Energy Resources									
Reduced Consumption	12.1	22.3	29.9	43.7	51.5	4[illegible]	40.5	210.0	15.0
Increased Efficiency	40.7	40.0	136.3	223.4	267.0	2[illegible]	315.5	1230.0	80.0
Subtotal	52.8	62.3	166.2	267.1	318.5	332.2	356.0	1440.0	95.0
2. Increase Domestic Production of Oil and Gas									
Production	12.8	11.2	31.7	89.1	79.5	59.5	50.2	310.0	50.0
Resource Assessment	7.2	8.3	20.0	23.0	29.5	37.5	40.0	150.0	40.0
Subtotal	20.0	19.5	51.7	112.1	109.0	97.0	90.2	460.0	90.0
3. Substitute Coal for Oil and Gas on a Massive Scale									
Mining			45.0	57.0	64.0	77.0	82.0	325.0	
Direct Combustion			30.0	35.0	40.0	44.0	51.0	200.0	
High-BTU Gasification			35.0	75.0	92.0	81.0	57.0	340.0	
Coal Liquefaction			75.0	75.0	75.0	75.0	75.0	375.0	
Low-BTU Gasification			30.0	37.0	42.0	48.0	43.0	200.0	
Synthetic Fuels—Industry Pioneering			100.0	100.0	55.0	50.0	50.0	355.0	
Environmental Control Technology			70.0	50.0	42.0	45.0	53.0	260.0	
Supporting Research and Development			20.0	22.0	24.0	27.0	27.0	120.0	
Subtotal	88.8	167.2	405.0	451.0	434.0	447.0	438.0	2,175.0	842.0
4. Validate the Nuclear Option									
Safety and Other	42.7	51.7	90.6	125.6	143.0	170.5	189.5	719.2	609.9
Uranium Enrichment	50.3	56.8	64.2	54.8	57.4	58.4	59.4	294.2	284.5
High Temperature Gas Reactor	7.2	14.2	40.0	44.7	24.2	26.9	28.0	163.8	128.6
Light Water Self-Sustaining Reactor	29.5	29.0	21.4	17.7	9.8	9.8	9.8	68.5	68.5
Liquid Metal Fast Breeder Reactor	253.8	356.8	477.0	538.6	510.8	524.2	506.0	2,556.6	2,470.6
Gas Cooled Fast Breeder	1.0	1.0	17.0	23.0	29.0	33.0	38.0	140.0	27.0
Advanced Technology	11.3	7.8	21.5	24.5	30.5	34.0	37.2	147.7	83.2
Subtotal	395.8	517.3	731.7	828.9	804.7	856.8	867.9	4,090.0	3,672.3
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible									
Fusion—Confinement	39.7	55.8	135.0	230.0	261.0	338.0	376.0	1,340.0	1,132.0
Fusion—Laser	35.1	42.9	10.0	20.0	25.0	25.0	30.0	110.0	
Solar	4.2	13.2	32.5	39.9	41.4	42.2	44.0	200.0	80.0
Geothermal	3.8	11.1	40.0	41.0	40.8	35.7	27.5	185.0	20.0
Subtotal	82.8	123.0	217.5	330.9	368.2	440.9	477.5	1,835.0	1,232.0
TOTAL	640.2	889.3	1,572.1	1,990.0	2,034.4	2,173.9	2,229.6	10,000.0	5,931.3

Table 2-6.—SUMMARY SCHEDULE OF SUPPORTING RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
Operating Expenses	1,062.1	1,311.0	1,451.4	1,519.3	1,618.8	6,962.6
Equipment	160.7	233.4	211.3	242.4	250.3	1,098.1
Construction	349.3	445.6	371.7	412.2	360.5	1,939.3
TOTAL	1,572.1	1,990.0	2,034.4	2,173.9	2,229.6	10,000.0

Table 2-7.—OPERATING EXPENSES FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

Self-Sufficiency Task	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	26.6	34.3	38.2	36.6	35.2	170.9
Increased Efficiency	112.2	155.5	178.8	190.2	216.0	852.7
Subtotal	138.8	189.8	217.0	226.8	251.2	1,023.6
2. Increase Domestic Production of Oil and Gas						
Production	26.0	70.2	67.6	51.6	45.9	261.3
Resource Assessment	14.8	19.8	24.7	31.5	33.7	124.5
Subtotal	40.8	90.0	92.3	83.1	79.6	385.8
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	28.5	34.5	36.0	41.5	45.5	186.0
Direct Combustion	12.8	18.4	10.9	12.4	13.3	67.8
High-BTU Gasification	12.5	24.0	47.0	49.0	53.0	185.5
Coal Liquefaction	52.0	38.0	38.0	40.0	45.0	213.0
Low-BTU Gasification	3.8	5.0	7.0	10.0	14.0	39.8
Synthetic Fuels—Industry Pioneering	46.0	45.5	50.0	44.5	44.0	230.0
Environmental Control Technology	42.0	25.0	22.0	30.0	47.0	166.0
Supporting Research and Development	18.0	20.0	21.5	24.0	24.0	107.5
Subtotal	215.6	210.4	232.4	251.4	285.8	1,195.6
4. Validate the Nuclear Option						
Safety and Other	74.8	88.5	104.6	117.6	130.6	516.1
Uranium Enrichment	44.1	47.0	48.0	49.0	50.0	238.1
High-Temperature Gas Reactor	20.8	21.3	22.8	25.3	26.3	116.5
Light Water Self-Sustaining Reactor	21.1	17.4	9.3	9.3	9.3	66.4
Liquid Metal Fast Breeder Reactor	303.6	361.3	380.4	390.6	382.3	1,818.2
Gas Cooled Fast Breeder	13.0	21.4	26.8	30.2	34.6	126.0
Advanced Technology	21.1	23.8	29.2	32.4	35.6	142.1
Subtotal	498.5	580.7	621.1	654.4	668.7	3,023.4
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion—Confinement	112.0	170.0	215.0	235.0	265.0	997.0
Fusion—Laser	8.0	17.0	22.0	22.0	27.0	96.0
Solar	21.2	22.4	21.5	19.3	19.9	104.3
Geothermal	27.2	30.7	30.1	27.3	21.6	136.9
Subtotal	168.4	240.1	288.6	303.6	333.5	1,334.2
TOTAL	1,062.1	1,311.0	1,451.4	1,519.3	1,618.8	6,962.6

Table 2-8.—EQUIPMENT OBLIGATIONS FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

Self-Sufficiency Task	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	2.7	6.2	8.7	4.2	3.5	25.3
Increased Efficiency	20.5	41.2	49.0	46.2	47.2	204.1
Subtotal	23.2	47.4	57.7	50.4	50.7	229.4
2. Increase Domestic Production of Oil and Gas						
Production	5.7	18.9	11.9	7.9	4.3	48.7
Resource Assessment	2.7	3.2	4.3	6.0	6.3	22.5
Subtotal	8.4	22.1	16.2	13.9	10.6	71.2
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	13.0	16.0	18.5	22.5	30.0	100.0
Direct Combustion	5.1	6.6	9.4	10.2	15.1	46.4
High-BTU Gasification	1.5	1.0				2.5
Coal Liquefaction	5.0	7.0	5.0	6.0	10.0	33.0
Low-BTU Gasification	1.0	1.7	2.0		1.0	5.7
Synthetic Fuels—Industry Pioneering	4.0	4.5	5.0	5.5	6.0	25.0
Environmental Control Technology	10.0	5.0	4.0	4.0	5.0	28.0
Supporting Research and Development	2.0	2.0	2.5	3.0	3.0	12.5
Subtotal	41.6	43.8	46.4	51.2	70.1	253.1
4. Validate the Nuclear Option	13.8	7.1	8.4	8.9	8.9	47.1
Safety and Other	5.1	4.8	6.4	6.4	6.4	29.1
Uranium Enrichment						
High-Temperature Gas Reactor	1.2	1.4	1.4	1.6	1.7	7.3
Light Water Self-Sustaining Reactor	0.3	0.3	0.5	0.5	0.5	2.1
Liquid Metal Fast Breeder Reactor	23.4	33.3	27.4	29.6	40.7	154.4
Gas Cooled Fast Breeder	1.0	1.6	2.2	2.8	3.4	11.0
Advanced Technology	0.4	0.7	1.3	1.6	1.6	5.6
Subtotal	45.2	49.2	47.6	51.4	63.2	256.6
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion—Confinement	23.0	49.0	24.0	58.0	35.0	189.0
Fusion—Laser	2.0	3.0	3.0	3.0	3.0	14.0
Solar	8.3	11.6	11.0	10.1	14.6	55.6
Geothermal	9.0	7.3	5.4	4.4	3.1	29.2
Subtotal	42.3	70.9	43.4	75.5	55.7	287.8
TOTAL	160.7	233.4	211.3	242.4	250.3	1,098.1

Table 2-9.—CONSTRUCTION OBLIGATIONS FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

Self-Sufficiency Task	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	0.6	3.2	4.6	3.6	1.8	13.8
Increased Efficiency	3.6	26.7	39.2	51.4	52.3	173.2
Subtotal	4.2	29.9	43.8	55.0	54.1	187.0
2. Increase Domestic Production of Oil and Gas						
Production						
Resource Assessment	2.5		0.5			3.0
Subtotal	2.5		0.5			3.0
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	3.5	6.5	9.5	13.0	6.5	39.0
Direct Combustion	12.1	10.0	19.7	21.4	22.6	85.8
High-BTU Gasification	21.0	50.0	45.0	32.0	4.0	152.0
Coal Liquefaction	18.0	30.0	32.0	29.0	20.0	129.0
Low-BTU Gasification	25.2	30.3	33.0	38.0	28.0	154.5
Synthetic Fuels—Industry Pioneering	50.0	50.0				100.0
Environmental Control Technology	18.0	20.0	16.0	11.0	1.0	66.0
Supporting Research and Development						
Subtotal	147.8	196.8	155.2	144.4	82.1	726.3
4. Validate the Nuclear Option						
Safety and Other	2.0	30.0	30.0	44.0	50.0	156.0
Uranium Enrichment	15.0	3.0	3.0	3.0	3.0	27.0
High-Temperature Gas Reactor	18.0	22.0				40.0
Light Water Self-Sustaining Reactor						
Liquid Metal Fast Breeder Reactor	150.0	144.0	103.0	104.0	83.0	584.0
Gas Cooled Fast Breeder	3.0					3.0
Advanced Technology						
Subtotal	188.0	199.0	136.0	151.0	136.0	810.0
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion—Confinement		11.0	22.0	45.0	76.0	154.0
Fusion—Laser						
Solar	3.0	5.9	8.9	12.8	9.5	40.1
Geothermal	3.8	3.0	5.3	4.0	2.8	18.9
Subtotal	6.8	19.9	36.2	61.8	88.3	213.0
TOTAL	349.3	445.6	371.7	412.2	360.5	1,939.3

Table 2-10.—OPERATING EXPENSES AND EQUIPMENT AND CONSTRUCTION OBLIGATIONS FOR FEDERAL SUPPORTING RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
Operating Expenses						
Environmental Research	88.5	98.5	111.0	125.7	137.1	560.8
Basic Research	39.0	52.1	59.6	60.7	59.2	270.6
Manpower Development	5.0	9.0	12.5	12.3	11.2	50.0
Subtotal	132.5	159.6	183.1	198.7	207.5	881.4
Equipment Obligations						
Environmental Research	5.9	9.9	10.5	18.7	6.2	51.2
Basic Research	4.0	5.9	6.4	6.3	6.8	29.4
Manpower Development						
Subtotal	9.9	15.8	16.9	25.0	13.0	80.6
Construction Obligations						
Environmental Research	11.5	13.5	7.0	3.0	3.0	38.0
Basic Research						
Manpower Development						
Subtotal	11.5	13.5	7.0	3.0	3.0	38.0
TOTAL	153.9	188.9	207.0	226.7	223.5	1,000.0

3

Energy Supply and Demand

The goals of the energy research and development program can be deduced from a brief analysis of the energy situation which sets out:

- Recent developments.
- The present situation.
- Desired future conditions.
- Measures required to attain those conditions.
- Research and development needs to make those measures possible.

RECENT DEVELOPMENTS

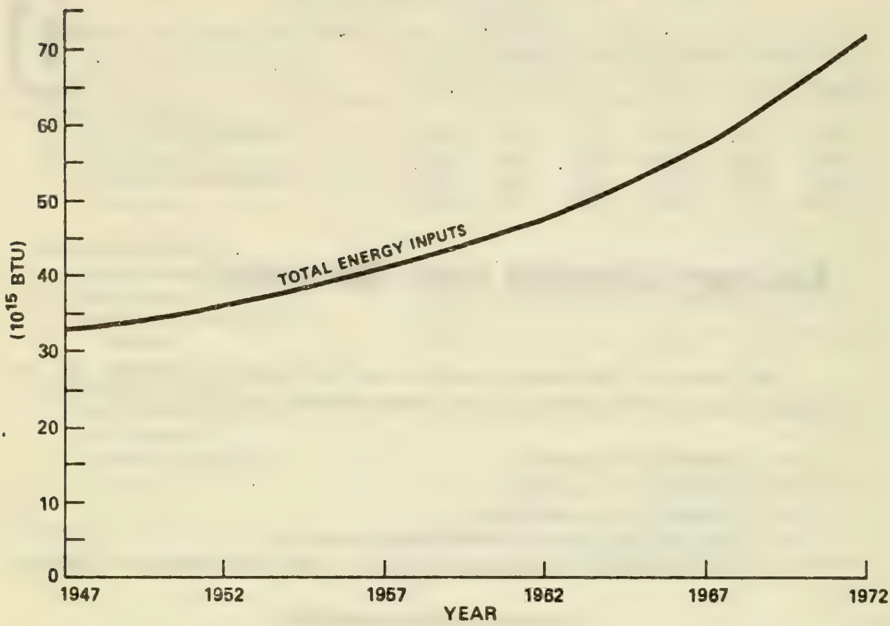
This Nation has until recently been blessed with abundant domestic supplies of readily accessible fuels. As a result, energy has been cheap relative to other commodities. Even today, United States energy costs relative to those of other commodities are less than in any other industrialized country, and these costs have declined over the last several years. In 1972 energy costs amounted to some 4% of the United States gross national product compared to 8 to 12% for most nations in Western Europe.

Until quite recently, energy has been produced from domestic resources in ways that seemed environmentally acceptable. Under these conditions United States consumption of energy has expanded enormously and at increasingly rapid rates, as shown in Figure 3-1. In 1972, with one-sixteenth of the world's population, the United States consumed more than one-third of the world's total energy production. The trend in absolute level of energy consumption is upward, although the United States share of total world consumption can be expected to fall as development proceeds in other countries.

About 25 years ago, major trends caused by market forces began to influence the energy system. The cleanest and most convenient fuels, natural gas and petroleum, were also the cheapest; so they began to displace coal. As

Figure 3-1

GROWTH IN UNITED STATES TOTAL ENERGY CONSUMPTION, 1947-1972



	Year					
	1947	1952	1957	1962	1967	1972
Total Energy Inputs (10^{12} BTU)	33,035	36,468	41,706	47,422	58,265	72,091
Five-Year Average Annual Rate of Growth (%)[1]		1.99	2.73	2.60	4.20	4.35

[1] These are average annual growth rates for each successive five-year period (e.g., 1947-1952, 1952-1957).

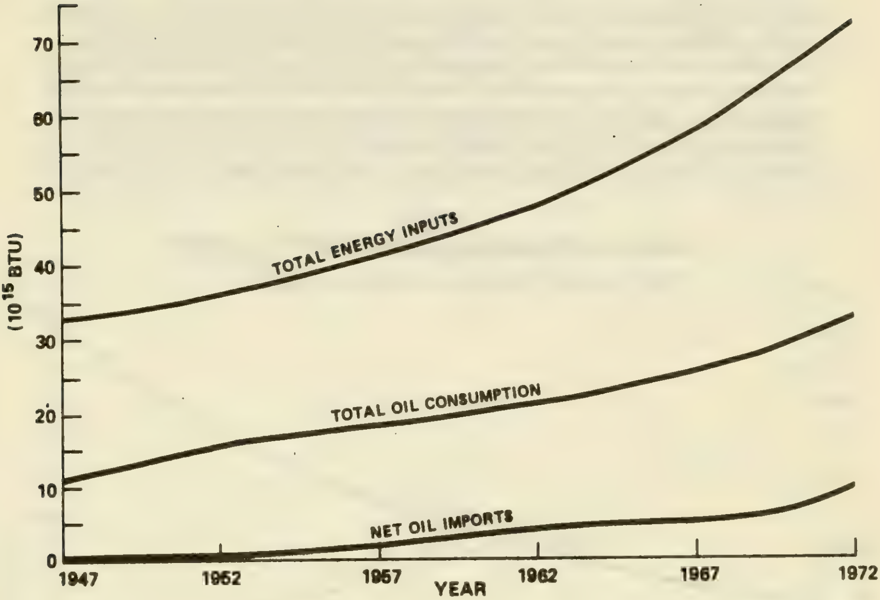
SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

consumption of petroleum began to outstrip domestic production rates, the United States began to import foreign oil because it was cheaper than domestic oil.

Although the Nation has been importing crude oil and refined products since the late 1940s, it was a net exporter of energy until 1958. Until then the energy value of coal exports exceeded that of oil imports. Figure 3-2 traces the growing contribution of oil and oil imports to our energy supplies. In 1957 the net imports of petroleum and petroleum products were 1

Figure 3-2

UNITED STATES OIL CONSUMPTION AND OIL IMPORTS, 1947-1972



	Year 1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,036	36,458	41,706	47,422	58,265	72,091
Total Oil Consumption	11,367	15,334	18,570	21,267	25,335	32,812
Net Oil Imports	10	1,186	2,253	4,222	4,841	9,588
Oil Imports as a Percentage of:						
Total Oil Consumption (%)		7.7	12.1	19.9	19.1	29.2
Total Energy (%)		3.3	5.4	8.9	8.3	13.3
Oil Consumption as a Percentage of Total Energy (%)	34.4	42.1	44.5	44.8	43.5	45.5

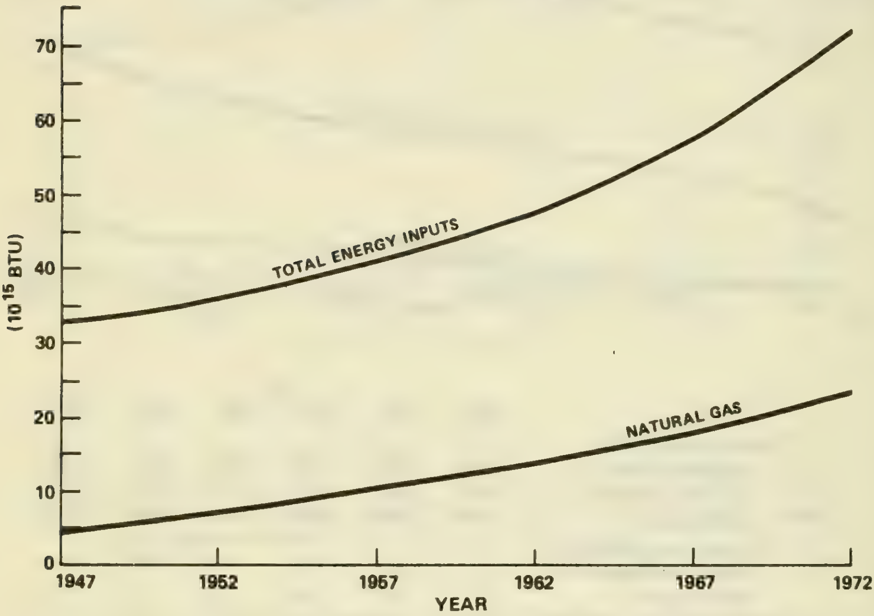
SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

million barrels/day. This represented some 12% of United States oil consumption, but only 5% of United States energy consumption at the time. The import levels grew slowly at first then rapidly in recent years. During the first half of 1973, the United States imported over 6 million barrels/day of oil, which represented about 33% of its oil consumption and about 17% of its energy consumption in that period.

Late in this same period, the rate of exploration for natural gas declined for two reasons. First, natural gas is often found in conjunction with or while seeking oil; however, with the discovery of cheap foreign oil sources, most oil exploration activity moved abroad. Second, a ceiling was imposed on the wellhead price of gas. As drilling costs rose and finding rates declined, the ceiling price reduced the incentive to drill for gas in the United States. With the price of gas lower than it would have been on the free market, gas consumption grew at an even faster rate than total energy consumption, increasing from 13% of total energy consumed in 1947 to 32% in 1972, as shown in Figure 3-3. Natural gas had all the advantages; it was cheaper,

Figure 3-3

UNITED STATES NATURAL GAS CONSUMPTION, 1947-1972



	Year					
	1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,035	36,458	41,706	47,422	58,265	72,091
Natural Gas	4,518	7,760	10,416	14,121	18,250	23,308
Natural Gas as a Percentage of Total Energy (%)	13.7	21.3	25.0	29.8	31.3	32.3

SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

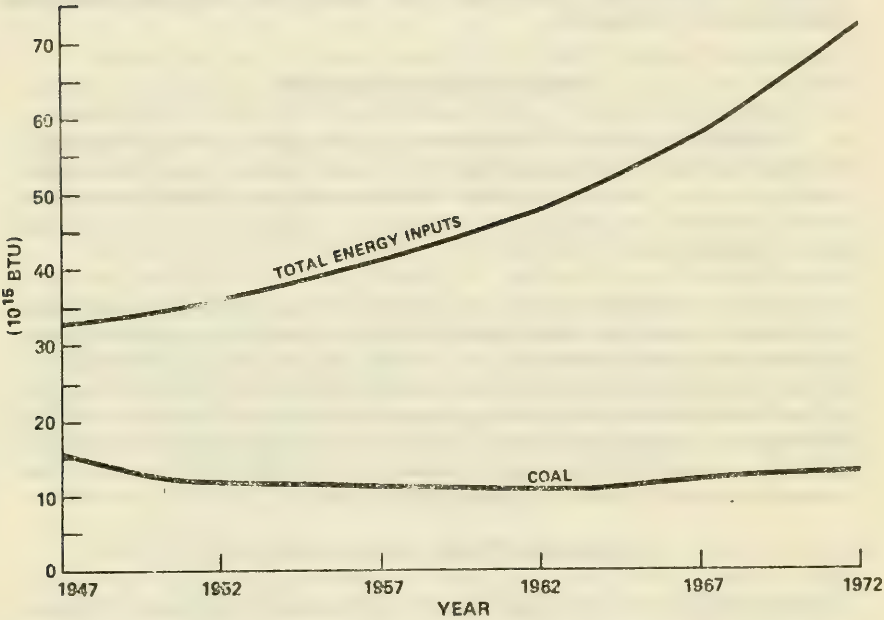
cleaner, and more convenient than other fuels, and its supply appeared to be ensured.

The gains in oil and gas use were made at the expense of coal. The share of coal in supplying total United States energy needs fell from 48% in 1947 to 17% in 1972. Details are shown in Figure 3-4.

More recently, environmental concerns led to the passage of the Clean Air Amendments of 1970 (P.L. 91-604), which set ambient air quality standards to be attained and maintained. Meeting these standards required

Figure 3-4

UNITED STATES COAL CONSUMPTION, 1947-1972



	Year					
	1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,036	36,458	41,706	47,422	58,265	72,091
Coal	15, 824	11,868	11,168	10,189	12,256	12,428
Coal as a Percentage of Total Energy (%)	47.9	32.6	26.8	21.5	21.0	17.2

SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

significant reductions in emissions of sulfur oxides from the stacks of most coal-burning processes. At that time most coal used had a high sulfur content; so the new emission standards accelerated sharply the shift from coal to oil and gas.

So long as supplies of oil imports seemed to be ensured, there was little cause for concern about domestic self-sufficiency. United States companies owned controlling interests in the firms producing and delivering foreign oil, and there seemed to be no practical limits on foreign production capacity. That much of the refining was done abroad and products were imported was no cause for concern so long as a continuous flow of fuel was reasonably ensured. Failure to use cheap foreign oil would have caused an unnecessary rise in the cost of energy at home and slower progress toward meeting desired environmental standards. The result has been an increasing dependence on oil imports.

THE PRESENT SITUATION

Suddenly a new set of conditions exists. A major portion of foreign oil supplies has been interrupted, and there are no readily available alternate sources for the quantity required. Consequently the United States faces major economic dislocations and unwelcome changes in the way its people live, work, and play.

Energy policy makers must choose among some undesirable alternatives to adjust to these new conditions. To absorb the sudden reduction in oil imports, the United States will pay a high price in some combination of dollars, environmental impacts, and social dislocations. The exact amounts of each required to balance energy supply and demand are determined by the state of energy production and use technology and by the behavior patterns of the producers and consumers of energy. The nature of the present emergency is clear; its dimensions are less so.

HOW FAR TO SELF-SUFFICIENCY?

The specifics of the energy supply and demand situation as of 1970 are displayed in Figure 3-5. Forecasts of the demand for energy and the contribution of the various fuel sources to meet that demand are based largely on projections of trends dictated mostly by economic considerations. A consensus of estimates of the 1980 energy situation past trends continued is shown in Figure 3-6. That consensus projected oil imports of 10 million barrels/day and gas imports equivalent to almost 2 million more barrels/day of oil. Clearly the energy situation in 1980 will have to differ by the equivalent of some 12 million barrels/day of oil from previous estimates if the Nation is to be self-sufficient by then.

In the face of current and projected shortages, the price of energy relative to that of other commodities will rise sharply. This rise will generate economic incentives both to conserve energy and to increase domestic supplies. The extent of these changes depends on:

- How fast the price rises.
- How high it rises.
- How long it maintains given levels.
- What consumers and producers expect to happen to future prices.
- Their responses over time to the pattern of actual and expected price increases.

None of these quantities is known.

One thing is clear beyond question: the Nation must exert every effort toward reducing the rate of growth in energy demand and increasing domestic energy supplies. The projected shortage of approximately 12 million barrels/day of oil equivalent by 1980 (Figure 3-6) did **not** incorporate the effects of the sharp rise in the price of energy expected in the near future.

Because the rise in energy cost will, of itself, restrain the growth of energy demand to some extent, the self-sufficiency target for increased production by 1980 will be something less than 12 million barrels/day of oil equivalent. How much less is not known with any confidence; one high-priority energy research and development objective must be to develop better methods for predicting that quantity.

Projections of the effect of price increases on moderating energy demand were developed as follows. If the real cost of energy doubles throughout the economy by 1980, an optimistic prediction would be to expect a 10% reduction in total energy demand in response to a doubling of the relative price of energy. This means that domestic supplies would still have to increase by the equivalent of something like 7.3 million barrels/day of oil if administrative rationing measures are to be avoided. An even more optimistic prediction—that a doubling of the relative price of energy would reduce the demand by 15%—would still require an increase in domestic production of about 5 million barrels/day of oil equivalent.

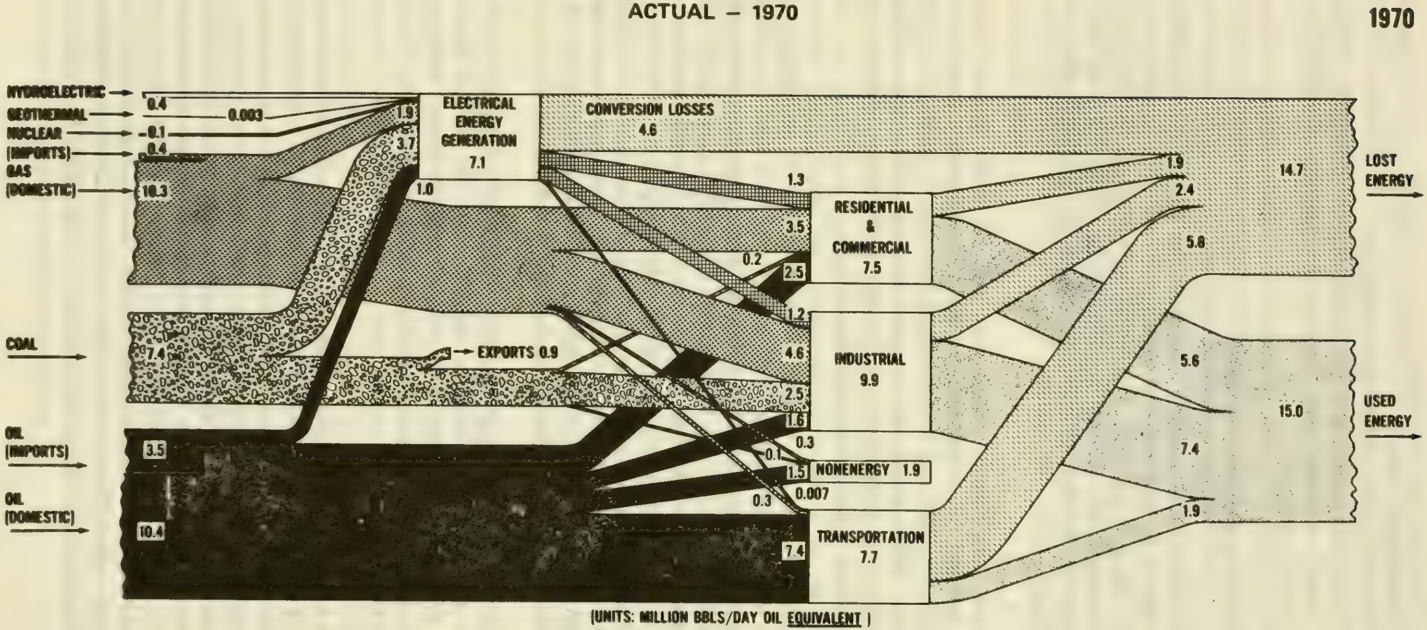
Clearly a major part of the burden of attaining self-sufficiency without controls must fall on increased supplies. For the United States to attain energy self-sufficiency by 1980, even if present energy costs are doubled, domestic supplies will have to increase by the equivalent of 5 to 7 million barrels/day of oil.

But the requirement to regain self-sufficiency does not stem from the present oil embargo alone. Figure 3-7 shows the expected long-range development of the Nation's energy future before the requirement to regain and sustain domestic self-sufficiency. Although estimates this far in the future are imprecise, this figure does show the relative magnitudes of the major transformations that were projected for the energy system. The huge bulge in projected imports is the most striking characteristic. The balance-of-payment implications of this level of imports in the face of competing claims from other users and restricted production rates by producing countries are reason enough in themselves to begin now to move

Figure 3-5

UNITED STATES ENERGY FLOW PATTERN

ACTUAL – 1970

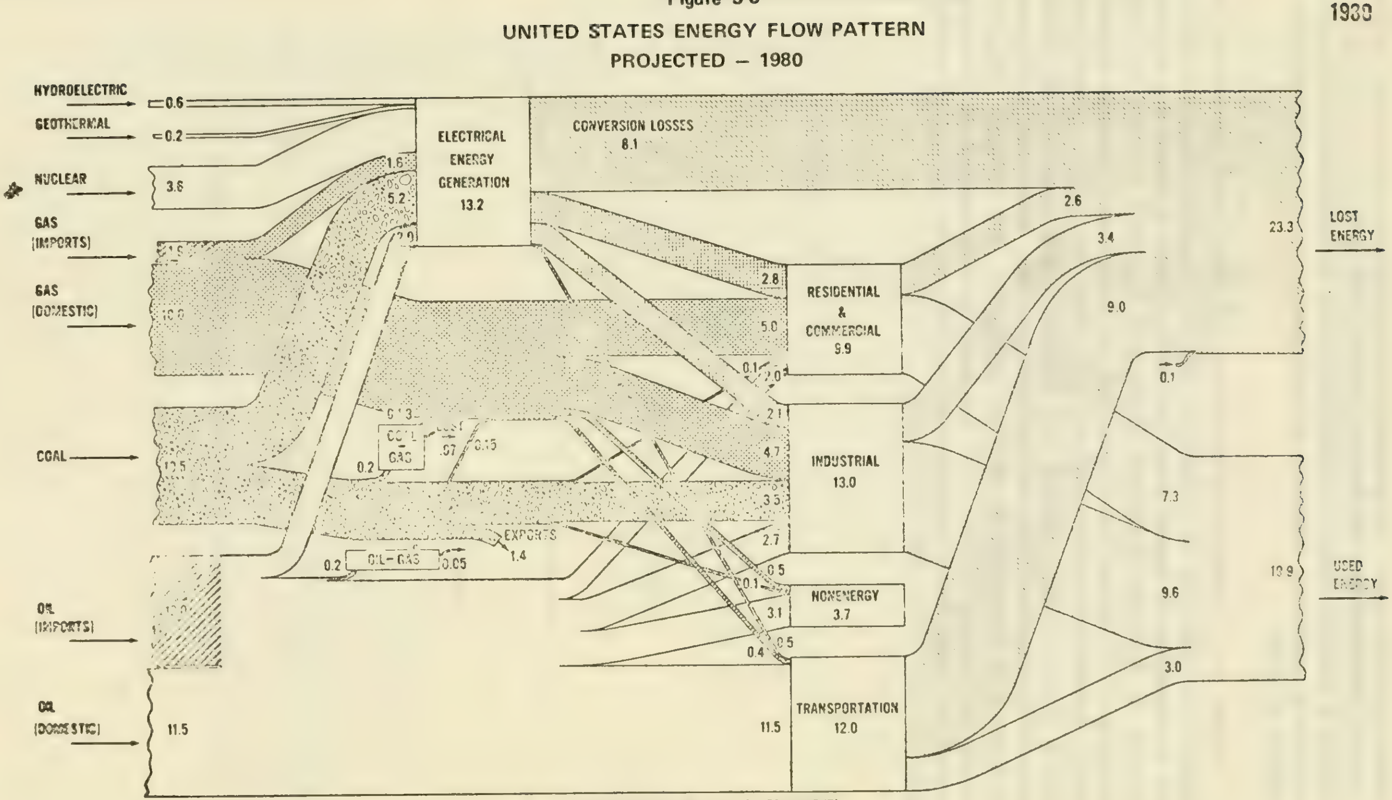


SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'." JCAE, 1973

Figure 3-6

UNITED STATES ENERGY FLOW PATTERN

PROJECTED – 1980



(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'," JCAE, 1973

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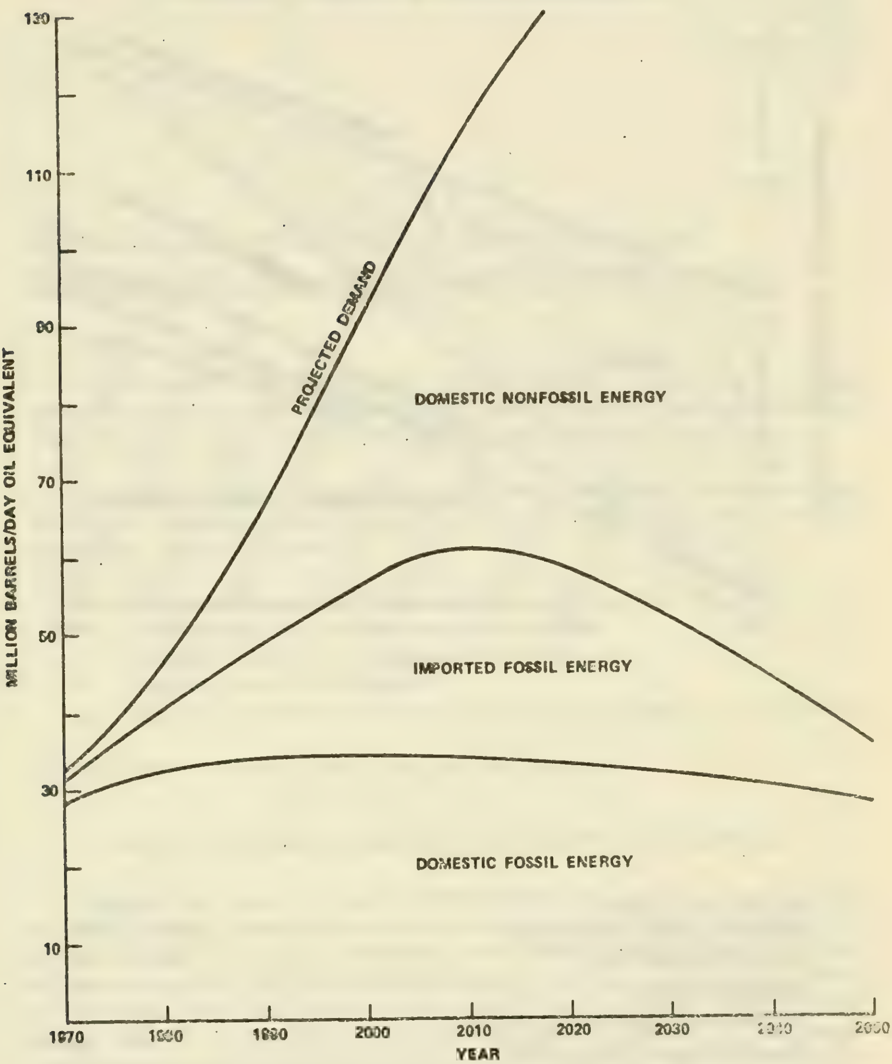
toward self-sufficiency. The present crisis has simply accelerated the time of a general awareness of the problem; it may well turn out to have been a blessing in disguise. Figure 3-7 also helps convey the magnitude of the job to be done in sustaining domestic self-sufficiency for any period after it is attained by 1980.

Figure 3-8, a modification of Figure 3-7, displays an estimate of the changes that will have to be made by 1980 in domestic energy production and consumption to regain self-sufficiency by 1980. It shows the dramatic increase in domestic fossil-fuel production that will be required, even assuming a 10% decline in the previously projected levels of energy demand. Such a fundamental change over the next seven years will be possible only with a vigorous energy research and development program and an equally vigorous production program that supports the early and widespread application of technological advances throughout the economy. The clear message in Figures 3-7 and 3-8 is that major transformations of the energy system are going to be required and the Nation must get started on them now.

Figure 3-7

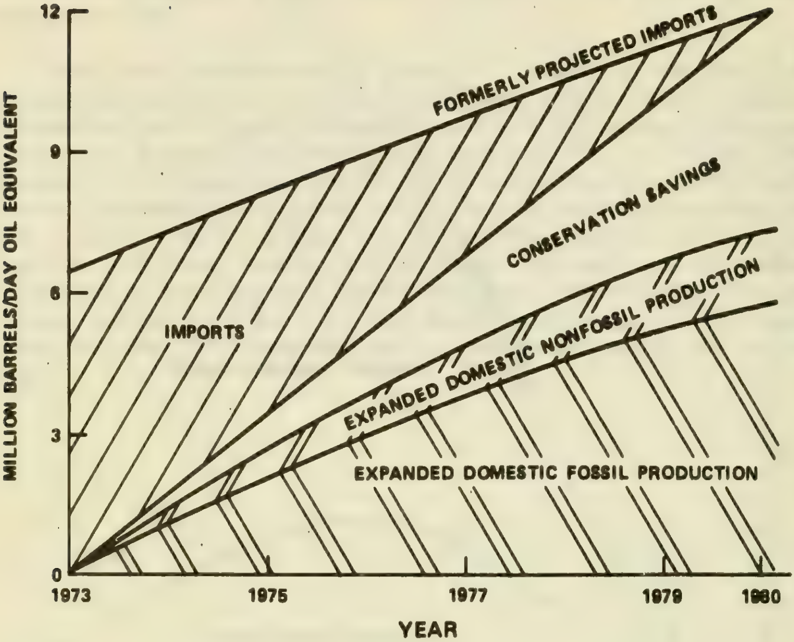
ENERGY FUTURE WITHOUT SELF-SUFFICIENCY



SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'," JCAE, 1973

Figure 3-8

SELF-SUFFICIENCY BY 1980 THROUGH CONSERVATION AND EXPANDED PRODUCTION



IMPORT REPLACEMENT (Million Barrels/Day Oil Equivalent)	YEAR 1973	YEAR 1980
Formerly Projected Imports	6.5	12.0
Conservation Savings*		4.7
Expanded Domestic Nonfossil Production		1.5
Expanded Domestic Fossil Production		5.8

*Includes both conservation techniques and energy real price increases.

4

Tasks Required to Regain and Maintain Energy Self-Sufficiency

The President has determined that the Nation should regain energy self-sufficiency by 1980. The Nation's longer term energy goal is to maintain that self-sufficiency at minimal dollar, environmental, and social costs.

Urgent research and development and supporting policy emphasis must be placed immediately and simultaneously on five major tasks to realize these goals. These five tasks are:

- Conserve energy and energy resources.
- Increase domestic production of oil and gas.
- Substitute coal for oil and gas on a massive scale.
- Validate the nuclear option.
- Exploit renewable energy sources to the maximum extent feasible.

The major features of these tasks are set out below.

TASK 1. CONSERVE ENERGY AND ENERGY RESOURCES

Every effort short of administrative controls, if possible, must be made to reduce energy consumption and to increase the technical efficiency of the energy system. There is an overriding need for knowledge about the effects of potential policy options and of price rises on energy consumption and for an extensive data base and a usable model of the energy system. Global policy analyses of the interactions among the components of the energy system are urgently needed to identify potential conservation opportunities and the measures required to exploit them. Information from such efforts can serve to guide immediate choices among policy options. For example, such analyses would identify as candidates for energy savings those activities most destructive of the environment which are deemed least essential to society's other goals.

At the same time, urgent attention must be directed to achieving the desired end-use energy consumption with fewer energy resources. This category of goals focuses on improving the efficiency of both stationary and mobile conversion processes and of transmission, distribution, and storage systems. Large savings might come from new ways of combining existing technologies to capture what is now waste heat from certain processes to do useful work. In general, gains in efficiency may be expected to reduce undesirable environmental effects and energy costs as well as extend the useful lifetime of our domestic energy sources. The immediate gain from conservation measures will be to minimize the extra production needed from domestic resources to regain self-sufficiency.

TASK 2. INCREASE THE DOMESTIC PRODUCTION OF OIL AND GAS

The role of oil and gas is so pervasive in the Nation's energy economy that the highest priority must be given to locating and recovering more oil and gas from domestic fields and to recovering more oil from shale. Secondary and tertiary recovery methods in existing fields, improved drilling methods for offshore sites, release of gas from tight formations, and extraction of oil from shale, offer much promise for immediate and short-term payoff. Scrupulous attention to environmental risks must be ensured, but such attention cannot be allowed to interfere with production increases. Rather, work must proceed at once on methods to prevent environmental damage, e.g., oil spills and well blowouts, and to clean up after accidents that do occur. Techniques must be advanced to contain the leachings from shale residue in confined areas. In situ retorting of shale, while problematical, could have very large benefits if successful.

TASK 3. SUBSTITUTE COAL FOR OIL AND GAS ON A MASSIVE SCALE

This task can be divided into two parts. The first is to switch wherever possible to the direct use of coal where oil and gas are now used, as in boilers in industry and in central power stations. This action can be taken almost immediately. The switch would be limited primarily by the amount of coal available, the transportation capability, and the availability of equipment to modify certain plants. Coal is an enormous domestic resource, and immediate and intensive efforts must be mounted to mine more of it and burn it at acceptable emission levels. "Front-end" processes that remove excess sulfur during combustion and "back-end" processes, such as stack-gas cleanup, must receive urgent and continued attention. Special attention is needed to determine quickly the appropriate balance between the removal of micron particles and the removal of sulfur oxides. Ambient air quality standards should be considered in conjunction with extensive instrumentation and monitoring to detect adverse effects at an early stage. Processes for solvent refining of coal should be explored on a priority basis. As with shale, in situ processes, though a high-risk area, offer the prospect of very high payoff if they can be developed.

The second part of the coal-substitution task is the conversion of coal to synthetic fuels: low-BTU gas; high-BTU, or pipeline quality, gas; liquid boiler fuel; and a synthetic crude suitable as refinery stock. Some existing methods are technically feasible; however, much work is needed to achieve improved yields. This is especially true for liquid fuels, where the technologies are less advanced and the estimated product costs are relatively high. A major effort must begin now to ensure these options.

The coal effort is a good example of how short-term and mid-term programs will support each other: many of the efforts directed at improving the yield, safety, and acceptability of mining and desulfurizing coal will readily apply to the more-advanced programs.

TASK 4. VALIDATE THE NUCLEAR OPTION

A self-sufficiency based on fossil fuels can only be temporary. Though large, these resources are finite. Statements about reserves adequate to last for hundreds of years seldom speak to the feasibility, let alone the desirability, of extracting them. Their extraction and conversion create major environmental problems, and the cost of energy will continue to rise as long as major dependence is placed on them.

Moreover, oil, gas, and coal are important sources of raw materials for fertilizer and other petrochemical industries. The world's growing demands for food alone preclude continued long-term reliance on fossil fuels as the Nation's principal source of energy.

As other nations develop economically, their fuel requirements will increase rapidly, much as did those of the United States. These requirements will place growing demands on the world's supply of fossil fuels. Many argue that the Nation has a responsibility to support its high standard of living from its own resources and a responsibility to leave some of its readily available fossil resources to future generations.

Finally, concern has been expressed about the possible eventual "greenhouse" effects of increasing the atmospheric concentrations of carbon dioxide resulting from the use of fossil fuels. Future limitations on worldwide carbon dioxide emissions may be necessary. All these reasons make clear the need to move as quickly as possible to replace fossil with nonfossil fuels for energy uses.

The Nation has already begun to exploit its nonfossil energy resources. Nuclear power now generates some 5% of all electricity, and this fraction is scheduled to increase to 23% by 1980. The projected increase must be ensured and accelerated. Nonfossil sources must increase sharply their already large planned contribution to the energy supply in the next decades.

The United States has a unique opportunity to exert world leadership by advancing the development of nonfossil energy technology. As reliance

on domestic fossil fuels begins to decline, the United States might export fossil fuels to other nations for a period. In the longer range future the export of nonfossil energy technology could be a major source of foreign exchange earnings and could help other nations free themselves from dependency on fossil fuels.

In the shorter term, research and development on reactor safety, waste management, fuel processing, and standardization of design is urgently needed to speed up the installation of nuclear reactors.

Accelerated research on converter and breeder reactors, to include use of the thorium cycle, offers promise of more-efficient power production and a great reduction in fuel requirements, with corresponding reductions of the problems created by mining, waste disposal, and radioactivity. Breeder reactors offer the promise of truly permanent self-sufficiency with minimal and eventually perhaps no extraction of ores. Additional effort must be directed to the elements of the nuclear fuel cycle from mining to reprocessing methods.

TASK 5. EXPLOIT RENEWABLE ENERGY SOURCES

For the long-term there is hope that environmentally clean, naturally renewed domestic sources of energy can be tapped at reasonable costs. Nuclear fusion and central-station solar power now appear to be the most promising prospects.

In the short-term and mid-term, however, much can be done and much yield can be expected from a sound program vigorously executed. For example, with available technology the economic feasibility and reliability of solar space heating and cooling should be demonstrated soon. Considerably more research and development must be done if significant amounts of the indirect sources of solar energy, such as wind currents, ocean thermal gradients, and bioconversion, are to be used.

5

The Federal Role in the National Program

The Federal Government's responsibilities in the national energy research and development program are to:

- Establish the goals of national energy policy, including those for energy research and development.
- Identify, in conjunction with private industry, the research and development needed to reach those goals.
- Ensure, through appropriate exchange of information with industry, that essential research and development is done by private sources, joint private and Government undertakings, or Government efforts.
- Accelerate technological advances throughout the energy system.
- Discharge these responsibilities in a manner consistent with the Government's nonenergy responsibilities.

Whenever national goals coincide with those of private industry, then private industry should be encouraged to attain the national goals. The free enterprise system has repeatedly demonstrated its ability to get results fast when given the proper incentives.

A competitive, free enterprise market is not well-suited to accomplish all the Nation's goals. Considerations, such as environmental concerns, basic research needs, and national security, that may not be readily integrated into the profit motive will not receive the necessary priority in the market. The Government should intervene to ensure adequate priority to considerations that are deemed necessary in the national interest, but are not funded by the private sector.

GENERAL GUIDELINES FOR FEDERAL/INDUSTRY PARTICIPATION

The major guidelines used in the development of the recommended program were to:

- Maximize industry participation, both to conserve Federal dollars and to speed the application of new processes.
- Tailor participation methods to individual industries.
- Ensure that no industry or firm realizes windfall profits at the taxpayers' expense, while preserving appropriate incentives that reward successful innovation.
- Use the best existing capabilities and expand Government facilities only when no capability exists nor can be created in the private sector.
- Press vigorously for the establishment of a single Government organization (Energy Research and Development Administration) to coordinate the national program and to plan, coordinate, and execute the predominant part of the Federal program.
- Develop Federal measures to reduce the commercial uncertainties of early application of new technologies.
- Ensure that efforts to attain energy goals do not unintentionally compromise efforts to attain other national goals (e.g., price stability, full employment, and consumer protection).
- Ensure that Federal actions taken in pursuit of other national goals also give full consideration to their impact on energy.
- Attain energy goals with minimal interference in the competitive market and in close coordination with Federal, state, and local regulatory agencies in regulated sectors.

The application of these guidelines and consultation with industry representatives show that the bulk of the private effort will be concentrated primarily on short-term objectives. Thus, the recommended Federal program does not include funds for all the short-term research and development contemplated in the national program. The best estimates possible suggest that with appropriate policies the Government might reasonably expect industry to allocate about $2.5 billion per year for direct energy-related research and development, most of it aimed at short-term payoff. The Federal program is designed to encourage private expenditures and to conduct needed short-term work over and above that expected to be funded by the private sector.

Based as it is on the profit and growth motives, the incentive for the private sector to undertake research and development expenditures diminishes as the expected time of payoff increases. Accordingly, the Federal share of the national program must be larger in meeting mid-term energy needs than in meeting short-term objectives.

Those efforts expected to yield major payoff only in the long term must depend almost entirely on Federal funding. Most of these efforts are in early stages of development and can be funded adequately without consuming a major share of the Federal budget for energy research and development.

The range of methods for Government participation extend from monitoring private actions to conducting research in Government facilities. Among the available methods are Government contracts for research and

development work, cost-sharing arrangements with private concerns, use of Government facilities by private investigators, guarantees of product price, guaranteed loans, guarantees of rates of return (as in utility regulation, for example), and tariff or quota protection of the domestic market to maintain a price structure that will stimulate private activity.

One of the hardest dilemmas that will confront energy policy makers is the need on the one hand for high prices and profits to stimulate private activity and the desire on the other hand to protect consumers against undue exploitation. The objective here should be to reward to the extent possible only private activity that involves new work or increased production while avoiding windfall or "unearned" profit increases to energy-producing firms.

Another series of dilemmas will arise as measures aimed at energy goals conflict with measures aimed at other national goals. Examples will be in areas of antitrust enforcement, taxation, leasing of public lands, patent rights, and attainment of ambient air quality standards as opposed to emission standards. In these areas tradeoffs among the goals will be required.

Finally, a series of incentives over and above research and development expenditures will be required to move the research and development results into production quickly to regain self-sufficiency by 1980.

In some cases the Government may have to offer contingent guarantees to industry to reduce risks to a level that will ensure both direct participation in research and development and early implementation of results. In such cases (guaranteed loans, guaranteed product prices, etc.), the Government incurs a contingent obligation similar to FHA or VA mortgage guarantees. These possible obligations are not included in the Federal energy research and development budget; they are treated as possible costs of realizing the most rapid impact on energy production.

Specific measures should be tailored to fit the particular industrial conditions. The requirement for a comprehensive and consistent set of Federal policies tailored to individual industrial conditions is only one very important reason why the early creation of a Federal Energy Research and Development Administration is essential to the successful execution of the national research and development program.

RESEARCH AND DEVELOPMENT STRATEGY OPTIONS

Energy policy makers will need to make choices among a number of competing considerations. Self-sufficiency, environmental improvement, and low energy cost are the three that are central to energy issues.

Energy research and development policy makers also must decide on the relative emphasis to be given in the Federal program to these considerations. The different priorities that can be placed on each constitute the available range of research and development strategy options.

With three considerations, there are ten possible strategies: A balanced strategy that gives equal emphasis to all three, and three in which each consideration is given first priority. For example, if self-sufficiency is accorded first priority, the three strategies under that condition are: second priority to environment and third priority to low cost, or second priority to low cost and third priority to environment, or equal priority to environment and low cost.

Two major reasons dictate the selection of the self-sufficiency/environment/low-cost strategy for the Federal program. First, the three possible self-sufficiency strategies are the only ones consistent with the urgent nature of the energy problems confronting the Nation and the support of the five tasks that have to be accomplished for the Nation to regain and sustain self-sufficiency.

Second, the competitive private sector already contains within it one of the most powerful incentives ever known to reduce costs: the profit motive. There is in the private sector no corresponding motive to move toward self-sufficiency. Also, the private incentive to clean up the environment is less compelling than the profit motive. Accordingly, the Federal Government should emphasize research and development programs aimed at regaining energy self-sufficiency achieved under acceptable environmental conditions and rely on the market forces to reduce energy costs.

The implications of this recommendation must be made clear. A significant and sustained rise in the price of energy relative to other commodities can be anticipated. As the price of energy rises, there will have to be some important changes in the way energy is used. Not all of them will be welcome, but the benefits of self-sufficiency can more than offset the costs.

CRITERIA FOR FUNDING FEDERAL PROGRAMS

Federal research and development criteria for assessing priorities among competing research and development programs and proposals include: the current state of scientific knowledge; the probability of future technological success; capital, resource, labor and environmental limitations on production feasibility and cost; and geographical, political, and other constraints on the application of new technologies. When allocating money, each program must be assessed for its probability of success, the investment of research and development funds required, the timing and extent of potential payoff, and noneconomic aspects.

The following questions should be considered when allocating funds for research and development projects:

- What will the project cost in each year to completion?
- What is the probability that the project will be successfully completed and when?

- If the project is successful, how long will it take to implement the new technology?
- What is the expected amount and timing of the gain from the scheduled implementation?
- What are the projected amounts and timing of the costs of realizing that gain?
- What is the "rate of return on investment" expected from each project (the present value of expected costs subtracted from the present value of expected benefits and the result divided by the present value of projected costs)?

Projects should be ranked in order of the size of the answer to the last question, then funded in sequence down that list to the limit of the money available for energy research and development if there are no overriding noneconomic considerations. If such considerations do exist, they and their implications for the program should be stated explicitly.

Precise and accurate estimates of the quantities involved are not required to get useful guidance from this approach. While absolute levels of the quantities involved are impossible to specify with precision because of future uncertainities, the direction and extent of differences in the magnitude among the various projects are much easier to estimate. More can be said about how projects might differ in the future than can be said about the absolute values of the crucial parameters. One way to do this is to set out the sequence of events that has to transpire for each project to be economically viable, then evaluate those sequences which are more likely and those which are less likely, and determine whether the differences are large or small. These kinds of estimates are sufficient to provide useful funding priority guidance.

A number of specific criteria can be identified, and estimates of "high," "medium," and "low" assigned to each program area. With these, semi-quantitative indicators (not measures) can be generated. These indicators can help specify the relative priorities among programs. Indicators so derived should not be used as inflexible decision rules. Rather, they can serve as useful inputs to informed judgments about the relative amounts of money that ought to go to the various programs.

A high indicator value does not necessarily mean a large number of dollars should go to that program; it means that the program should receive all the reseach and development dollars that can be spent prudently in the area. How many dollars can be spent prudently is a determination that must come from an informed judgment of the program's history, its present position, and the prospects for its future development.

Because of the claims of higher priority programs, a low-value program may have to be held to a funding level well below that which could be spent prudently. The absolute number of dollars going into a low priority program may still exceed that going into a high priority program because of differences in the scope of the programs concerned. For example, conservation studies may be the highest priority program, but may be able to

absorb prudently only a few tens of millions of dollars, while the nuclear fusion effort, having lower priority, calls for more money, yet still less than it could absorb prudently.

To be successful in augmenting energy supplies or reducing demand, a research and development proposal must show promise of success in three successive stages and must not be inconsistent with overriding noneconomic considerations. The four areas of inquiry and the major considerations in each are:

Research and Development Stage

- Adequacy of scientific base
- Probability of future technological success

Implementation and Production Stage

- Production capability
- Availability of ancillary resources
- Environmental cost consequences

Payoff Stage

- Timing of payoff
- Economics of payoff

Noneconomic Considerations

- Environmental effects not considered in costs
- National security
- Political
- Regional

A detailed explanation of the application of these criteria is contained in Appendix B. The results can provide useful guidance in the assignment of relative priorities for funding. Program rankings derived from the analysis are listed in Table 5-1 for the major elements of the recommended program.

The program rankings are not, **and are not intended to be**, definitive; they are **indicative** of the appropriate relative funding priorities derived from the recommended energy research and development strategy. They are a means by which program priorities may be estimated in the presence of large uncertainties about specific future results.

Concern is often expressed as to the availability of ancillary resources (water, transportation, land areas, manpower, capital) to support the application of a prospective new technology. While these deserve some consideration, they should not exert a major influence on **research and development** funding for two reasons.

Table 5-1

ILLUSTRATIVE PROGRAM PRIORITIES BASED ON CRITERIA

Weighted Criteria	Total Rank	Unweighted Criteria	Total Rank
Conservation	(70)	Conservation	(43)
Resource Assessment	(68)	Coal and Shale Processing	(42)
Oil and Gas	(67)	Resource Assessment	(41)
Coal and Shale Processing	(67)	Oil and Gas	(40)
Mining Coal and Shale	(65)	Fission	(39)
Fission	(63)	Mining Coal and Shale	(39)
Conversion Techniques	(55)	Conversion Techniques	(36)
Advanced Transportation Systems	(54)	Advanced Transportation Systems	(35)
Energy and Fuel Transportation Distribution and Storage	(53)	Energy and Fuel Transportation Distribution and Storage	(32)
Geothermal	(45)	Fusion	(29)
Fusion	(43)	Geothermal	(28)
Solar	(40)	Solar	(27)

First, one of the aims of the research and development itself is to reduce the major technical obstacles to implementation. Thus, a presently perceived obstacle that can be reduced is a call for more research and development, not less.

More importantly, only as application begins can realistic evaluations of these supporting resource requirements be made and the amount of the limited resources that will go to a particular energy technology be determined. All the resources needed to implement all the technologies in the research and development program exceed the available supply, but this does not mean that any research and development work should be curtailed. It means only that not all technologies are going to be implemented at their maximum possible rate. Those which are implemented, and the speed with which this is accomplished, will be decided largely by the success of the research and development program and by the market, where the users of each process must bid away from other users enough resources to support its application. The results will be reflected in the energy price from that technology, as well as in the prices of other commodities that use the same resources.

Management of the Federal Program

Two key elements are urgently required in the management of Federal energy research and development if it is to be successful: unity of effort and and flexibility.

Unity of Effort. The preceding section described one method for considering all the Nation's energy research and development needs in a

common framework. The importance of such unified consideration in planning the program is self-evident. The necessity for unified direction and coordination of the program's execution is equally if not more urgent.

A first requirement for making the most rapid possible progress toward self-sufficiency is a comprehensive and detailed inventory of the opportunities for increasing production from each of the energy sources, increasing the efficiency of energy transformation and distribution, and decreasing energy and energy resource consumption. These must be defined according to common standards and evaluated by the same criteria used to determine the potential impact on the self-sufficiency goal. Centralized direction of this effort will be essential to charting the alternate paths to self-sufficiency, selecting the most sensible path for major emphasis, and providing backup options in case of delays. A single Government agency will be required to accomplish these tasks effectively.

For example, some of the early questions that will have to be resolved in the program's execution can only be answered sensibly by a single group with overall responsibility for the program. The balance between total systems approaches and the role of major systems components is one such question. Work must begin at once on all the component areas by making the best estimates possible of values for the parameters of major components (e.g., how much will oil and gas production increase; how much must coal production increase; how much coal will go to each use?). At the same time, the total system must continue to be better defined so these parameters can be adjusted as work proceeds and initial results are obtained.

Other crucial questions will relate to what kind of work and how much of it is performed in Government laboratories and in industrial facilities; technical vs. institutional or policy measures to increase production; speed of application vs. environmental constraints; speed of research work vs. cost of the final process; when to freeze a design and go for application rather than seek continued improvements; how much effort to divert to immediate concerns vs. the effort going to more distant concerns; and a host of others. The way these issues are resolved at the outset of the effort will have a major impact on the shape of the entire effort. Failure to provide unified, coordinated guidance and direction in their resolution will invite if not guarantee the program's failure. A plan for a national research and development program and the money to carry it out are only two of the four essentials of success. The other two are an effective management structure and vigorous execution responsible to changing conditions.

Flexibility. The remaining essential requirement for conducting an effective program of the dimensions recommended with the urgency demanded by our energy situation is the ability to adjust to changes as they occur. By its nature research and development is an expedition into the unknown. New knowledge, new discoveries of resources with existing techniques, and a host of other facts will generate rapid shifts in the needs of individual programs.

The specific five-year program recommended herein appears now to be that best suited to the Nation's needs, but it will have to be modified in light of new circumstances as it is executed. The fiscal year 1975 budget recommendations are firm; they are the way to start the program. But estimates for future years and even program totals should be subject to continuing review and evaluation in light of changes in the Nation's energy situation.

Flexibility in the application of funds and their transfer among programs will be essential to the capability to exploit success. Changes in priorities and reallocation of effort among programs and between the Federal and private sectors will be required. Again, only a single agency with the authority to make such shifts can capitalize on opportunities as they are discovered and shut off failures as they are identified.

Finally, flexibility in the approaches to dealing with industry will be required. The coal mining industry, the coal using industries, the oil and gas industries, the transportation industries, and others all differ in fundamental respects. What works best in one industry may be totally wrong in another where conditions differ. Accordingly, the ability to set specific goals and constraints and to select, from among the possible Federal measurements, that combination best suited for each sector will be crucial to the most effective Government/industry cooperation.

Because the majority of the energy production system is privately owned, effective Government/industry cooperation will be essential in translating the program results into increased supplies. Wherever possible, some form of cost-sharing and participatory decision making should be used.

When only government management and funds are involved, there may be a tendency to extend a project beyond the reasonable point of cutoff, even when it is apparent to the potential industrial users that the undertaking no longer holds reasonable promise for producing useful results. Industrial management and partial industrial funding provide a method for subjecting programs to the discipline of the market place and redirecting resources in a timely manner.

International Cooperation

A final need for a centralized management capability derives from opportunities for cooperative international efforts in energy research and development. A recent interagency task force has identified the criteria that should apply in such efforts and the most promising prospects for international cooperation. The task force considered international research and development against a backdrop of four basic issues:

- Which technologies offer promise for cooperative research and development, and which countries are doing significant work worthy of cooperation?
- Should the programs be bilateral or multilateral?

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- What role should U.S. industry play, and can and should the Government stimulate industrial participation?
- What will be the technology transfer and balance of trade implications of increased cooperation?

The following criteria were used to establish priorities for cooperative research:

- Useful foreign technology.
- Impact on U.S. energy deficit.
- Time to commercial utility.
- Lack of barriers to information exchange.
- Opportunities to expand cooperation.

The five criteria refer to the potential benefit to be derived from cooperative research and development, and not whether the technology in question is necessarily high on the list of current U.S. domestic priorities. The task force reached the following judgement:

- High overall priority: coal technology, geothermal, energy conservation, environmental studies, resource assessment, and transportation systems.
- Medium overall priority: conversion technology, fuel transport, fusion, hydrogen economy, reactor safety, and solar.
- Low priority: electrical transmission, energy storage, hydro, miscellaneous sources such as wind and tidal power, all other nuclear, and oil and gas technology.

Clearly a single Government agency working in conjunction with the Department of State could better realize the potential benefits from such a program and integrate them into the planning and execution of the national and Federal programs than can the existing organization, or lack thereof, for Federal energy research and development.

6

Obstacles to Realizing National Energy Goals

This chapter describes basic technological obstacles that stand in the way of decreasing energy demand and increasing energy supply and institutional factors that may act as further constraints on the choice of programs to overcome energy shortages.

TECHNOLOGICAL OBSTACLES

Task 1. Conserve Energy and Energy Resources

Reduce End-Use Consumption. Significant results in energy conservation in the absence of administrative controls cannot be attained until research has been conducted to overcome:

- Insufficient knowledge of the effects of alternative policy options.
- Inadequate data for predicting the extent to which energy consumption is responsive to increases in the relative cost of energy.
- Inadequate identification of opportunities for substituting energy-conserving practices and processes for energy-intensive ones throughout the economy.
- Lack of an adequate data base and of models for systematic analyses of the energy system and the interactions of its major components.

Improve Efficiency of Energy Use. Ways must rapidly be found to meet a given end-use energy demand with fewer energy resources.

Industrial processes use approximately 40% of all energy consumed in the United States today. Industrial processes, equipment, and methods, whether dependent on heat or on electric power are inefficient. Major increases in efficiency are possible, as demonstrated by a few pioneering industry studies. A chloride electrochemical reduction process for aluminum production is substantially more efficient than the next best alternative and

also cleaner. The payoff of increased efficiency in all types of energy uses will be prompt and continuing, reducing resource use and the environmental impact of energy production and use. Major gaps in current technology are:

- Insufficient development of catalysts to substitute for heat or electric energy.
- Inadequate methods for using the waste heat of power plants and industrial processes for process heat and for space heating.
- Inadequate methods for using waste process heat to generate electricity.

Space heating and air conditioning account for almost 25% of all energy consumed in the United States today. Heating and cooling efficiency is largely dependent on building design and on the design of the conditioning unit and its control mechanisms. Future construction and modifications of present buildings should incorporate concepts leading to greater energy efficiencies. The building industry is so fragmented, however, that there is no prospect of significant impact without Government incentives, and the diverse building codes enacted by the multiplicity of independent jurisdictions complicate the problem of adopting standard designs. Principal limitations to greater efficiency are:

- Lack of a total-systems approach to the energy needs of individual buildings and clusters of adjacent buildings.
- Lack of coordination of the solar heating and cooling approach with building design.

The transportation sector accounts directly for about 25% of total fuel use and more than 50% of oil consumption. Shifts of travel practices from truck and auto to more-energy-efficient modes could reduce significantly the total energy demand and local pollution levels. Major obstacles to the shift are:

- The lack of general public acceptance of mass-transportation vehicles and systems in their current form.
- Inadequate data about the response of citizens to incentives to make more efficient use of cars.

Conversion Techniques. The conversion of fossil fuels and nuclear fuel to electricity is a relatively inefficient process. The newest central-station power plants typically have efficiencies of about 38 to 40%; the overall industry average is nearer 30%. The remainder is lost in the form of waste heat, which contributes to pollution. Demand for electricity has grown more rapidly than that for other forms of energy; its doubling rate is now 10 years.

To supplement the regular steam cycle, generating plants could, with so-called "topping cycles," use the high-temperature spectrum of the combustion gases. These include magnetohydrodynamic (MHD) cycles, liquid-metal cycles, or direct turbine drive by the hot gases before they are used to form steam. An increase in overall system efficiency of 15% is

theoretically possible; the savings in fuel would be enormous (in the range of 25% or more), and waste-heat rejection would be reduced by as much as 40 to 45%, which would decrease environmental problems as well. The need is urgent for work on:

- High-temperature gas turbine, potassium topping cycle, and magnetohydrodynamics.
- Materials for use with high-temperature working fluids.
- Cost and life of fuel cells.
- Scale factors for commercial-sized equipment.
- Heat rejection and utilization technology for base-load plants.
- Methods for combining different technologies and processes to achieve greater efficiencies and reduce total heat rejection.

Energy Transmission, Distribution, and Storage. Once electric energy is generated at a power plant, it may travel many miles to the consumer. In the process, voltages are stepped up and down. In general, the higher the voltage, the smaller the losses in transmission, but the higher the capital requirement for the line. Transmission lines are designed to optimize the trade-offs between these economic factors. The ever-increasing demand for electric energy will require more power lines in the future and power lines of increased capacity. Major difficulties are:

- Resolution of land-use and visual-impact problems to permit use of more efficient, higher capacity overhead transmission systems.
- Costly, inefficient underground cables with inadequate capacity.
- Instantaneous matching of generation to load within and between electric power systems.
- Lack of adequate, efficient energy storage systems.

Advanced Transportation Systems. Transportation uses 25% of all energy consumed in the United States at an efficiency that rarely exceeds 20%. Furthermore, automotive and aircraft engines today are designed to run only on refinery products of crude oil, a pattern that cannot be changed significantly in the near future. Because of their intolerance for fuel substitutes, automotive and aircraft engines may set the lower limit on needs for liquid petroleum products. The supply of natural gas, which is a suitable alternate fuel, is even more constrained than that of liquid petroleum. When an automotive engine converts fuel to mechanical energy, there are other losses in the automotive power train that further reduce system efficiency. Moreover, vehicles are designed to optimize features other than fuel economy. Primary technological blockages to change are:

- Lack of vehicles designed to provide efficient transportation service with minimum fuel consumption.
- Lack of automotive engines that are both highly efficient and environmentally acceptable.
- Inability to use substitute fuels and fuel supplements (e.g., methanol) on a large scale.
- Inefficient automotive power trains.

Task 2. Increase Production of Oil and Gas.

Oil and Gas. The ratio of proven domestic reserves to production for both oil and gas continues to fall. The recovery of oil from operating fields averages only some 30% of the oil in place and is only some 40% in the newest fields. Every 1% increase in recovery rates presents an addition of 4 billion barrels to U.S. proven reserves, an amount equal to about two-thirds of present annual consumption.

Much gas exists in impermeable rock formations and cannot presently be recovered economically. Moreover, theories that explain the formation of hydrocarbon resources predict the existence of large undiscovered reserves. Large areas contiguous to the continental United States may contain undiscovered reserves, although some of them may exist at depths that cannot be explored and tapped economically with today's exploration and drilling techniques. Major technical obstacles to a rapid increase in domestic production of oil and gas are:

- Lack of economic recovery methods for oil and gas remaining in producing fields.
- Lack of recovery methods for gas trapped in impermeable formations.
- Lack of economic discovery and recovery methods for oil and gas at great depths.
- Inadequate methods for preventing large oil spills and for containing and cleaning up spills with minimum damage.

Shale Deposits. Oil can be produced by retorting shale to generate a crude-oil product from the hydrocarbon-rich kerogens of the shale deposits. Both nonnuclear and nuclear methods of fracturing rock offer promise of releasing the shale in forms suitable for in situ retorting. Shale as a source of oil has the advantage that its BTU content per barrel of produced oil is slightly higher than that of the natural petroleum product. In addition, shale has a higher hydrogen content than does coal; so less hydrogen is needed to produce the liquid fuel. Some 75% of the richer shale deposits are located on federally owned property. Major recovery problems are:

- Lack of economically viable and technically reliable methods for retorting shale deposits, especially in situ.
- Lack of adequate technology for fracturing shale deposits in situ.
- Lack of environmentally acceptable methods of handling the shale debris generated by above ground retorting.

Task 3. Substitute Coal for Oil and Gas

Mining and Direct Use of Coal. The energy content of known domestic coal reserves is significantly larger than that of any other energy resource available with today's technology. However, the use of coal has dropped sharply in the past two decades (Chapter 3). Approximately 60% of coal reserves have a sulfur content that is so high that combustion emissions will

not meet air quality standards without the use of new emission-control techniques. The decline in the use of coal has resulted in a contraction of the industrial base. Major obstacles to the use of coal are:

- Lack of proven techniques for reclaiming surface-mined areas, especially in semiarid and arid regions.
- Low productivity of underground mining methods.
- Limited ability to burn high-sulfur coal in ways that meet established pollutant (sulfur oxides) emission standards.
- Production of undesirable waste products by current stack-gas scrubbing methods.
- Lack of effective methods for removing micron particulates from stack gases.

Production of Gas and Oil from Coal. *Low-BTU Gas from Coal.* Oil and gas have been produced from coal for many years. The technology was used in Germany during World War II, but it has not been economically competitive with other sources of oil and gas. Before natural gas was widely used as an energy source, synthetic gas was manufactured from coal. It is acceptable by modern standards. A gasifier using air should be able to produce a clean low-BTU fuel that could be burned in most fossil-fired electric utility boilers as well as in smaller industrial boilers. Only 35 to 40% of the original heat content of the coal would be lost in the conversion process. Rapid installation of improved gasifiers could be expected in the utility industry. The principal impediments are:

- Inadequate development of gasifiers for low-BTU product.
- Lack of a high-temperature desulfurization process to clean up the gas.
- Lack of advanced techniques to salvage the excess heat loss.
- High cost of transporting low-BTU gas.

High-BTU Gas and Liquids from Coal. Processes for producing high-BTU gas and liquids from coal rely on increasing the ratio of hydrogen to carbon over that found in coal. Given sufficient price incentives, industry should be able to produce high-BTU gas from coal at costs competitive with naphtha conversion, imported liquified natural gas, or natural gas transported from Alaska. The product from liquefaction processes contains less than half the hydrogen necessary to make pipeline-quality gas from coal but less of the original heat value is lost in the process. The liquid product is also easier to transport and store. Principal obstacles to production are:

- Need for a breakthrough in production of hydrogen by catalysis or other methods.
- High cost of producing methanol from coal.
- Lack of methods to remove organically bound sulfur in coal.
- Insufficient knowledge about engineering needs to accommodate various grades and types of coal.
- Environmental constraints, particularly the availability of water supplies.

Task 4. Validate the Nuclear Option

Current Nuclear Reactors. The present generation of converter nuclear reactors is being installed at a rate well below original expectations. In addition to construction delays, licensing delays, and environmental and safety concerns, the evolutionary nature of the industry has resulted in continual design changes in successive reactors. Each new design modification has required a full-scale review for licensing by the Atomic Energy Commission. The current plans for high-level waste disposal call for storage of fission-product waste above ground for up to 100 years while a permanent disposal method can be developed. There is an urgent need to improve the following conditions:

- Inefficient fuel utilization of present light-water reactor designs.
- Shortage of experimentally confirmed test data on environmental and safety problems associated with converter reactors.
- Plutonium and fission-product waste handling and disposal problems.
- Lack of standardization in reactor design and site selection procedures.

Fuels. The current family of nuclear converter reactors uses a relatively inexpensive fuel derived from high-grade uranium and thorium ores. Known reserves of these high-grade ores are limited, and medium-grade ores have not been well explored. To support the expected growth in nuclear power plant capacity, the uranium mining industry must expand its output fivefold in the next 12 years. Obstacles to expanded use are:

- Lack of techniques for mining rich uranium ores without making lower grades of ore less accessible for future mining.
- Need for more-efficient enrichment techniques.
- Need for more-efficient fabrication and reprocessing techniques.

Breeder Reactors. Breeder reactors (Liquid Metal Fast Breeder, Gas Cooled Fast Breeder, Molten Salt Breeder, etc.) are necessary to provide longer term sources of energy from nuclear fission because supplies of low-cost fissionable material are limited. The development of fuels and materials in turn will dictate reactor-design concepts. Work must be done on:

- Technical fuel and materials problems associated with breeder reactors.
- Excessive doubling time and specific fuel inventory of current designs.

Task 5. Exploit Renewable Energy Sources

Geothermal. At several locations geothermal energy has already been harnessed in the form of dry steam (Geysers, California) or hot water (Wairaiki, New Zealand), but such locations are rare and do not contribute significantly to the energy supply. Larger reservoirs of geothermal energy exist in the form of hot rock, hot brine, geopressurized zones, and magma.

Many such sources contain heat energy at temperatures that are too low for use in conventional power-generation systems. Other sources contain contaminating salts or other minerals. Technical impediments to early increased use are:

- Lack of economical ways to find and assess geothermal reservoirs and determine their nature.
- Absence of recovery and use techniques for low-temperature or contaminated geothermal resources.
- Minimal understanding or control of potential environmental insults (earthquakes, tremors, and disposal of vast amounts of noxious gases, minerals, and salts) that might result from substantial geothermal exploitation.

Solar. For many years solar energy has been used directly on a small scale to heat water for homes or provide heat to grow plants. Unless solar energy is concentrated, however, the temperature rise associated with solar heating is too low to produce power with conventional generating techniques. Weather and day-night variations make the supply of solar energy intermittent and require that storage systems be provided for times when sunlight is inadequate.

Decentralized solar systems for space heating, water heating, and air conditioning in buildings are technically feasible today. Operating costs are appealing, but initial capital costs are high. Thus, there is no significant market force to create the necessary industry. Demonstrations with Government buildings might help stimulate a significant market for commercial buildings in the near future. Principal constraints are:

- Inefficient solar-energy collection technques.
- Inefficient energy storage techniques.
- High capital costs for decentralized heating and cooling systems.

Fusion. If fusion reactors become technically feasible, the world's oceans will provide an inexhaustible supply of fuel. Several approaches to the concept are being explored. Although recent successes are encouraging, demonstrating technical feasibility and completing the necessary reactor concepts will take considerable time. Principal difficulties are:

- Lack of adequate testing facilities to conduct critical scientific experiments.
- Lack of knowledge as to which, if any, of the suggested approaches will lead to success.
- Insufficient development of materials for planned reactors.

General Requirements

Environment. Energy production and use have been major contributors to detrimental changes in air, water, and land quality. Increasing per capita consumption of energy has been directly related to increasing insult to the

environment. The relationship must be altered if desired environmental standards are to be attained.

It has only recently been realized that efforts to increase the standard of living through increased energy use may have undesirable environmental impacts. As a result, research has been initiated into the nature of these impacts, which arise from all phases of the energy cycle from fuel exploration and extraction to energy conversion and waste management. Major gaps include:

- Inadequate knowledge of the physical and chemical transport processes by which pollutants become distributed in the environment and find their way to man.
- Lack of knowledge about the health, ecological, welfare, and social impacts of various energy systems and the pollutants they generate. Such knowledge is vitally needed to set standards, to establish guidelines for the siting of energy systems, and to direct research to control and ameliorate these impacts.

Basic Research. Fundamental knowledge of the physical, biological, economic, and social laws that govern living patterns and the properties of matter has been the cornerstone of man's increasing control over the forces of nature. The energy system of the Nation is so complex that there is not a single discipline that does not play some part in its functioning. Increases in fundamental knowledge should lead to greater understanding, and such understanding should contribute to more efficient operation of the system.

Much technological development has been characterized by empirical process development. More often than not it has become difficult to move beyond certain barriers because of a lack of fundamental knowledge. In such cases, basic disciplines have been called upon to determine what relationships existed and to find approaches to overcoming the problem. With recognition of the energy shortage and with forecasts of increasing shortages for many years, maintaining the competence to react quickly to such calls for assistance is essential. Broad areas for basic research reflect:

- Insufficient knowledge of the physical and chemical nature of matter.
- Insufficient knowledge of biology and biological processes.
- Insufficient knowledge of the economic and social interactions of man.

Systems Analysis. The complexities and dynamics of the United States energy system are such that it is virtually impossible to discern even the major interactions that occur throughout the system or to predict the effects of changes to the system. Systems analysis is presently limited by:

- Lack of a valid energy model.
- Lack of a valid up-to-date data base for the model.

INSTITUTIONAL CONSTRAINTS ON TECHNOLOGICAL DEVELOPMENT

Federal and State Environmental Laws and Regulations

The National Environmental Policy Act (NEPA) of 1969 was a significant recognition by the Congress and the Administration that our national growth could no longer continue uninhibited by concern for the environment. The Act requires that an Environmental Impact Statement be published in draft form no later than 90 days before a "significant Federal action" is taken that could have an effect on the environment. A final report must be published no later than 30 days before that action. Recent court interpretations of the Act and guidelines dictate that the impact statements must be developed to support Congressional authorization and appropriation for the "activity." Thus all new or significantly altered programs will require the preparation of Environmental Impact Statements before authorization or appropriations.

Environmental standards issued by either the Federal Government or state governments should not be considered constraints to technological development. Rather, they set requirements for research and development that must be met if the technology is to be implemented within the respective jurisdictions. There is considerable concern about the validity of many such standards that have been based upon incomplete data and analysis or a complete lack of knowledge regarding the impact of certain pollutants on the environment. For instance, a major technological objective is to determine the effects of pollutants on the ecosystem and its inhabitants. That determination could establish a firmer basis for environmental standards, and the standards, in turn, would determine technological objectives for research and development efforts.

The pace of development of particular types of energy may ultimately be related to public acceptance. Delays in the environmental research program could result in significant delays in the preparation of environmental impact statements, licensing of power-generation facilities, and the implementation of various energy technologies.

Land Use and Water Mangement

The use of land for energy-related activities, such as fuel extraction, siting of fuel-conversion and power-generating facilities, transmission-line rights-of-way, and waste-management requirements, is becoming a significant factor. Regional and national management policies must be developed to accommodate competing needs for land and water for development of energy resources, wildlife conservation, recreation, irrigation and agricultural programs, and lumber and paper-pulp industries. Mining and reclamation and especially conversion processes for coal require large amounts of water, and water is not plentiful in those areas of the West where vast reserves of coal are located. An equitable distribution of land and water resources to competing claims must be devised. Such an integrated policy will be required to maintain the Nation's scenic beauty and ecological integrity as it meets its energy needs.

Federal and State Laws and Regulations Governing Health and Safety of Miners and Industrial Workers

The enactment of such laws as the Operational Safety and Health Act (OSHA) has had a widespread impact on industry, generally in terms of increased requirements for capital expenditures to provide much-needed additional safeguards for workers' health and safety and has also resulted in decreased productivity.

New technological developments should produce equipment and methods that are consistent with the laws and regulations. As such, the laws and regulations are not constraints to technological development but are an objective of such development.

Manpower Availability for Research and Development

In the late 1960s, employment opportunities for scientists and engineers declined owing largely to the termination of large programs in the aerospace industries. More recently, conditions have stabilized, and employment among scientists and engineers is high. A major increase in research and development funding could require a major increase in scientific and technical personnel.

If major increases in research and development funding are directed into new fields, the pace may be limited by the rate at which investigators can be educated, trained, or retrained to work in those areas. More importantly, most of the program categories comprising energy research and development are multidisciplinary. They rely on many of the same disciplines for both research and development. A shortage of trained manpower can create a competitive atmosphere that could result in spiraling wages and relatively inefficient use of research and development dollars. Currently the number of proposals for energy and energy-related research and development projects by firms and individuals in academic positions indicates that manpower is available for additional work.

The universities and industry have the greatest potential for producing new scientific and technical manpower. Research and development funds channeled to them would produce, in addition to increased knowledge, a large working force for future research and development. This force would comprise both undergraduate and graduate students and older workers retrained for new fields. Trained personnel can be retrained within a year or two and well-trained graduate students can be produced within two to three years.

These limitations on the growth of an available manpower pool and the hazards of attempting to radically increase funding for programs that would compete for scientific manpower dictate that extreme care be exercised in designing the energy research and development program for the next five years. If major acceleration is necessary in certain program areas, such acceleration may entail costs not only in dollars but also in the loss of

capability to enhance or continue research and development in some competing programs.

Government Policies Concerning the Exchange of Information Between Large Corporations (Antitrust Laws) and Patent Rights

The public and privately owned electric utilities are regulated and have formed the Electric Power Research Institute (EPRI) to use funds charged to the rate base to conduct research and development of benefit to the entire industry.

By contrast, companies in the oil industry are specifically precluded from joining together in such a venture. As a result, each oil company must work on its own research and development goals; much duplication results. Since different oil fields have different physical characteristics, a wide variety of techniques has been developed for drilling, control, production, and stimulation of oil and gas. If each company could benefit from the experience of others, the net result should be more efficient operations and greater production. What does not exist and is precluded from existing is a central clearinghouse for research and development data and information that is in the hands of individual oil and gas companies. If solutions are developed by individual companies, proprietary rights could preclude widespread application or even application in regions where most appropriate. The oil industry is spending more than $600 million annually for research and development. With existing constraints, however, coordinated programs in the industry leading to the necessary solutions are not possible.

The oil industry has been reluctant to undertake cooperative efforts with the Government because rights to proprietary data could be compromised. Both patentable and unpatentable data are involved.

The same is true for other industries. Individual companies fear that funds invested in research and development would not be returned if the benefits are afforded to the industry as a whole.

The concept embodied in EPRI partially solves the problem by permitting the industry to share the risk as well as the benefit. When only one company or a part of the industry has an interest, however, it should be accorded some right to the advantages of research and development when it shares risk with the Government. It appears inconsistent to assume that, because taxpayers' dollars are spent to enhance the public good, an industry that risks capital along with the taxpayer should not be allowed to derive specific benefit. This area needs much consideration.

Government Policies Concerning Leasing of Federal Lands

Much of the oil, gas, oil shale, and geothermal resources and reserves in the United States are on public lands or beneath U.S. waters. The exploration and exploitation of those lands requires Government consent

through leasing. Many such areas have not been opened to leasing, and vast reserves and resources have yet to be tapped. Although the outer continental shelf in the Atlantic Ocean may contain as much or more oil and associated gas than the Alaskan North Slope, there is as yet no leasing program for that area, and exploitation cannot be undertaken.

A similar situation exists for the oil-shale reserves located in the Piceance Creek Basin of western Colorado. About 75% of the rich shale deposits are located on federally owned property. Although the development of these areas is not primarily a research and development function, the lack of an adequate assessment of the potential resource base is a significant obstacle to energy policy formulation and research and development planning.

Market Uncertainties

Industry cannot predict with any degree of certainty future market conditions, e.g., the effects of the rising prices of imported oil and the regulated price of natural gas. The significance of these conditions lies in the fact that projected shortages in the supply of these commodities probably will not be overcome by private incentives as long as major market uncertainties exist.

Short-run self-sufficiency can be attained only by imposing measures that reduce the demand for energy to the maximum amounts that can be supplied from domestic resources. Other policy decisions that permit the maximum increase in domestic production will be required to realize short-term increases in the production of energy from domestic resources. Measures to increase domestic supply must continue with a view to relaxing the nonmarket measures imposed to reduce consumption. The first step in this direction is to accelerate the implementation of existing technologies for producing energy from domestic resources.

The overwhelming majority of the domestic production capability resides in the private sector. Private-sector investment decisions are made on the basis of expectations regarding future prices of energy rather than current prices. Thus, in the absence of Government policies to reduce the commercial uncertainties of increasing domestic production, there will be a substantial time lag in the implementation of existing technology until domestic producers are convinced that the high prices are going to prevail for long enough to make their investment profitable.

Moreover, other obstacles to rapid construction of additional domestic production capacity must be removed. Leasing policies that make available potential sources of domestic fuels must be devised. Guarantees of prices, guarantees of rates of return on investment, tax write-off policies, depletion allowances, and other risk-sharing measures to reduce the uncertainty of commercial ventures to acceptable levels must be considered. The dilemma confronting the Federal Government is that risk-reducing measures may diminish the incentive for private-sector research and development efforts aimed at reducing the costs of domestic production.

Capital investments for supporting functions may become limiting. For example, transportation of coal to market or to distant conversion plants will require revitalization of the rail industry or construction of special slurry pipelines.

There are two fundamental difficulties with a market approach to achieving domestic energy self-sufficiency. The effectiveness of the approach depends on the expectations of private producers about the continued high level of energy prices for substantial periods in the future. Given the potential availability of cheap foreign sources of energy materials, private producers must weigh carefully the risks of a major investment in a high-cost technology, using domestic resources. Supplies that can be cut off quickly can be turned on again as quickly. A private producer who makes a major investment in an oil-shale plant that can produce and sell oil for $5 a barrel can find himself in an untenable position if, soon after production begins, oil at $3 a barrel becomes available from foreign sources. Thus, relying primarily on market forces to generate increased domestic production implies an extended period of administrative controls to restrict consumption to available domestic supplies.

Research and development expenditures are justified for a commercial enterprise only with the expectation that they will lead to a sufficiently large increase in profits to provide an acceptable rate of return, compared to alternative uses of the limited capital available to the firm. In a situation without government-guaranteed product prices, there is no assurance that a private concern would find major research and development expenditures, with all the uncertainties involved, an attractive investment compared to additional productive capacity at guaranteed prices or rates of return.

7

Objectives of the National Energy Research and Development Program

The technical and scientific obstacles and the various political, environmental, manpower, and legal constraints to implementation of vitally needed energy technologies have been discussed in the previous chapter. The accelerated energy research and development program recommended in this report is designed to overcome these obstacles as expeditiously as possible.

It is essential in planning a balanced research and development program both to meet short-term needs and to ensure the means of meeting the needs of the decades beyond the short-term. The current scientific and technological limitations on various promising programs are reflected in the time required before commercial application of program results can be implemented. In this chapter the specific technological objectives sought for the time periods defined as short-, mid-, and long-term are summarized. This listing indicates the allocation of effort according to the different time periods within which the beginning of commercial payoff is expected.

NEAR- OR SHORT-TERM (PRESENT TO 1985)

This category includes research and development objectives that enhance the implementation of existing technologies, identify additional resources, and improve the efficiency of existing techniques, practices, and processes. Particular attention is given to removing barriers to public acceptance, satisfying existing standards, and developing an improved basis for standards in all energy production and use areas. In the list that follows, objectives with most immediate commercial payoff in energy production or conservation are marked with a •.

Task 1. Conserve Energy and Energy Resources

- • Identify and quantify energy-conserving practices and processes throughout the economy.

- Develop a model of the energy system and an appropriate data base; use the model to improve the quantitative understanding of the energy system and its interactions and to assist managers to better plan and manage energy research and development.
- Increase the efficiency and capacity of electrical transmission and distribution systems, both above and below ground.
- Increase the efficiency and capacity of energy storage systems.
- Develop combined-cycle technology.
- Develop materials and technologies for high-temperature "topping cycles," including potassium topping cycles and magnetohydrodynamics.
- Demonstrate techniques and consumer incentives that shift demand to more efficient transportation modes for people and goods for both urban and inter-city travel.
- Evaluate and demonstrate vehicle designs that optimize fuel economy and develop more efficient engines that are environmentally acceptable.

These objectives will enhance the efficiency, acceptability, or resource base of existing energy technologies. Progress in achieving these objectives will help attain the goal of energy self-sufficiency and will clarify choices among mid-term and long-term energy research and development goals as time goes on.

Task 2. Increase the Domestic Production of Oil and Gas

- Demonstrate effectiveness of new and currently available methods for secondary and tertiary recovery from existing oil and gas fields and publicize results.
- Develop methodologies to recover gas from tight formations.
- Improve methods for assessing potential oil and gas recovery from offshore sites and oil shales.

Task 3. Substitute Coal for Oil and Gas on a Massive Scale

- Improve emission-control technology for coal, especially with second-generation stack-gas cleaners.
- Mine coal with improved techniques and more effective reclamation.
- Improve gasifiers for production of low-BTU gas.
- Enhance supplies of hydrogen for coal conversion technologies.
- Develop materials for the construction and operation of coal conversion plants and develop methods for handling solids, including grinding, transporting, and separating from liquids.
- Demonstrate economic viability and reliability of the conversion of coal to gas and oil.

Task 4. Validate the Nuclear Option

- Evaluate environmental and safety problems associated with converter reactors.

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- Standardize nuclear reactor site selection procedures.
- Demonstrate safe procedures for handling and storing radioactive materials, including plutonium.
- Develop long-term disposal procedures for radioactive wastes, including plutonium.
- Improve enrichment techniques for uranium.
- Improve fuel fabrication and reprocessing methods.

Task 5. Exploit Renewable Energy Sources

- Reduce capital costs for solar heating and cooling units.
- Find and assess potential reservoirs of geothermal energy.
- Develop improved methods for extraction of heat from geothermal sources.
- Assess potential dangers of disturbing geological formations by extracting geothermal resources.

MID-TERM PERIOD (1986-2000)

Mid-term energy research and development program goals aim at providing alternative energy sources and increased ability to substitute more plentiful fuels for scarcer ones. Conservation and efficiency measures, conversion of coal to gas and oil, breeder reactors, and certain solar and geothermal sources are prime elements of the mid-term program. The long lead time for development and implementation of these promising technologies makes it urgent to accelerate funding now to meet expected energy demands more than a decade from now.

Task 1. Conserve Energy and Energy Resources

- Demonstrate gains in efficiency from combined-cycle technologies.
- Develop engines capable of using a greater variety of fuels.

Task 2. Increase the Domestic Production of Oil and Gas

- Demonstrate the economic viability of oil recovery from oil shale.

Task 3. Substitute Coal for Oil and Gas on a Massive Scale

- Improve the economic viability and reliability of conversion of coal to oil and gas.
- Develop improved catalysts for fuel conversion processes.
- Maintain efforts to assess and minimize environmental impacts of energy production.

Task 4. Validate the Nuclear Option

- Demonstrate economic viability and reliability of various breeder reactors.

- Evaluate environmental and safety aspects of breeder reactors.
- Develop fuels and materials for advanced reactors.

Task 5. Exploit Renewable Energy Sources

- Demonstrate methods to produce significant amounts of electricity from direct solar incidence, from ocean thermal gradients, from wind, etc.
- Develop photovoltaic, thermoelectric, and bioconversion techniques to a significant level of productivity.
- Demonstrate economic viability of advanced geothermal methodologies.
- Demonstrate technical viability of thermonuclear fusion technologies.

LONG-TERM PERIOD (BEYOND YEAR 2000)

Many presently unanticipated variables, of course, will become important in the long-term period. Changes in the organization of society, in the patterns of transportation and other energy uses, in the needs of industry, and in overall economic growth patterns may occur. The long-term goal of the energy research and development program for self-sufficiency is the production of adequate amounts of environmentally clean, low-cost fuels from relatively inexhaustible domestic sources. Energy should be available in forms best suited to the energy needs of the various sectors of the economy. Specific objectives include:

Task 1. Conserve Energy and Energy Resources

- Improve technologies for conversion of fuels to electricity.
- Improve methods for transmission, distribution, and storage of energy.

Task 5. Exploit Renewable Energy Sources

- Develop large-scale direct and indirect solar-energy conversion programs.
- Develop methods for producing hydrogen in large quantities at low cost.
- Develop fusion technologies to economically viable status.
- Provide advanced materials for fusion reactors.

Supporting Programs

Certain supporting objectives in closely allied areas must be pursued as complements to the specific energy objectives set out above. The most important of these are:

- Enhance basic research into energy systems and fuel sources.

- Continue basic research into chemistry, physics, geology, and biology to identify new potentials and provide the basis of knowledge for solution of problems that experience shows will arise.
- Establish the nature, emission patterns, distribution in the environment, and ecological and medical effects of pollutants.
- Provide improved bases of knowledge for setting environmental standards and minimizing environmental impacts from energy technologies.
- Develop detailed methods to enhance environmental and ecological integrity and overcome any necessary but undesirable impacts that have accumulated.
- Create and sustain an adequate supply of scientifically and technically competent manpower to support the operation of the energy system and the research and development program.

Analysis of these objectives and the time period when they are currently expected to be achieved is a useful input to the process of designing a balanced national energy research and development program.

Appendix A

FY 1975-1979 ENERGY R&D PROGRAMS AND SUPPORTING PROGRAMS

This appendix outlines the recommended national energy research and development program and supporting program. The appendix includes discussions of:

- Program Goals
- FY 1975-1979 Program Objectives
- Contributions to the Energy System If Success Is Achieved
- Program Plan
- Supporting Evidence
- Budget

TASK 1—CONSERVATION

A. REDUCED CONSUMPTION $210M

Program Goals:

1. End-Use Conservation $150M

To conserve energy and energy fuels by reducing the rate of growth in consumption and to achieve this reduction while maintaining an acceptable standard of living and environment, under conditions of minimal social and economic dislocation.

2. Improved Management .... $ 60M

To conserve energy, energy sources, and energy research and development resources by providing analytic tools for comparative analyses of alternative energy strategies that will assist energy policy and energy research and development policy decision makers in establishing policies.

FY 75-79 Program Objectives:

1. End-Use Conservation

a. To maximize specific energy efficiency in buildings by developing and demonstrating improved design, construction techniques and practices, operational methods and maintenance practices, and use of materials that require less energy for production.
b. To reduce energy consumption in industrial processes by developing and demonstrating improved design, construction techniques and practices, operational methods, and maintenance practices and the use of materials that require less energy for production.
c. To increase the energy efficiency of transportation systems by developing and demonstrating more efficient utilization of alternate modes, patterns of traffic flow, coordination of systems to urban growth patterns, and use of local regulations.
d. To demonstrate the energy efficiencies to be derived from integrated utility systems that would provide a community with all utility services from a single plant.
e. To develop appropriate information and data, with cross-energy-sector applications, for analysis of the implications of demographic trends, land use alternatives, and new technologies in terms of their impact on energy demands.

2. Improved Management

a. Develop and maintain an adequate base of information and data on and improve existing and develop new quantitative models of the U.S. energy system in order to provide the analytical tools required for analyses of alternative energy policies or management concepts.

b. Conduct assessments, including evaluation of environmental, economic, and social factors, of emerging energy technologies and integrate the results of those assessments into evolving national energy policies and strategies.
c. Develop evaluation criteria for the selection of energy research and development strategy alternatives and identify the trade-offs implicit to these alternatives.
d. Develop recommendations for systematic management of energy research and development including identification of total resource needs and the allocation of those resources among competing programs, taking into consideration the appropriate roles for Federal and private funding.

Contributions to the Energy System If Success Is Achieved:

1. End-Use Conservation

The potential savings available through the application of conservation measures are obviously very large and difficult to predict. A 20% savings by 2000 is a conservative estimate. If 30% of the existing buildings in the U.S. are modified so that their heating and cooling loads are reduced 40% and 30%, respectively, a savings of 3% of the present total annual energy used in the U.S. will be realized.

If 50% of the new buildings built each year incorporate energy conservation design features that result in a 40% savings in consumption, a total savings of 15% of the present U.S. consumption would be realized at the end of 10 years.

Ultimately a 30% reduction in primary fuel requirements for industrial thermal processes is a realistic goal, through improved thermal processes and waste energy utilization.

Improved transportation efficiency, especially improved auto occupancy and improved management of freight, could reduce projected transportation demand by about 5% by 1978 and 10% by the year 2000.

Market analysis shows that Modular Integrated Utility Systems (combinations of various utility services in a single facility) can be utilized to service 16% of all new construction. Based on this estimate, energy requirements for space heating, hot water, air conditioning, and electricity in new construction can be reduced 35% by 1986—a reduction of 8.5% of total energy requirements for residential utilities.

2. Improved Management

Improved management planning using modern analytic techniques and a current data base can provide a means for rapid objective assessment of energy system requirements, trends, capabilities, and limitations. The decision maker would have at his disposal a more rational basis for assessing

trade-off options and the allocation of resources to meet either energy needs or research and development requirements. Viable options for program planning can be analyzed to optimize payoff with minimum expenditures of resources.

Program Plan:

1. **End-Use Conservation**

Since too little is known about the specific opportunities for research and development leading to more efficient equipment, building, and process design, early program emphasis must be on problem definition and program design and formulation. The FY 1975 objectives and expenditures must, if necessary, be applied to "software"—or studies leading to program formulation. That activity will be supplemented by an acceleration of those programs already underway where specific objectives are clear (e.g., Modular Integrated Utility Systems—MIUS).

The software results are expected to include numerous proposals for "hard" research and development activities that can be begun immediately, and a rapid rise in program funding levels is anticipated. Concepts for energy conservation abound, but their implicit effects are essentially unknown. Once those effects are better defined, it should be possible to move directly to demonstration projects in many fields. Other "software" results are expected to specify the need for more research and development on component or material design that would result in a rapid rise in laboratory experimentation.

2. **Improved Management**

Improved management must begin with the development of an open-ended data base and models that will provide for forecasting of impacts and estimated results of various research and development efforts. A second level of effort will be directed toward analyzing those alternative models on a quantitative basis and translating the results into management tools for evaluation of research to be undertaken and research and development underway.

Supporting Evidence:

1. **End-Use Conservation**

The general subject area of process and utilizing-device efficiency is so broad that a primary necessity exists to define those topics of highest potential "payoff" before detailed technical investigation is begun in earnest. The range of disparity between theoretical requirements for energy and actual use patterns shows that there is a wide range of opportunities for increasing efficiency. Land, building, and equipment designers and contractors, industrial users of energy, and the individual consumers comprise a widely disparate field of potential research and development

partners. Clearly, only the Federal Government can lead in such a fragmented area of investigation, development, and demonstration. It should be noted that many governmental pricing research and development regulatory policies have been based on an effort to promote cheaper or more abundant energy. Effort will be needed to smooth a transition from some of these policies.

Research and development conducted under the aegis of the Government can produce new standards for performance and design that would support policy incentives by the Executive and the Congress, and demonstration of more efficient designs can lead to the adoption of new equipment, methods, and construction that will produce savings for the user as well as the Nation.

2. Improved Management

Systems and planning analysis functions exist in all Government agencies that are currently active in energy or energy-related research and development. Such functions are necessary for program management and analysis. However, there does not exist the technological base for management and analysis of energy policy and research and development. Decision makers are forced to rely on multiple data bases and systems for analysis purposes. Both central policy coordinators and individual program directors can benefit from centralized planning and analysis models in addition to the requisite agency support offices.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	5 Yr. Total
End Use Conservation						
Buildings	6.2	10.0	11.0	11.6	11.2	50.0
Industry	5.4	9.0	14.0	12.8	13.8	55.0
Transportation	1.8	4.2	4.5	3.0	1.5	15.0
Integrated Utility Systems	4.5	5.0	4.0	1.0	0.5	15.0
Cross Energy Sector Studies	2.0	3.5	4.0	3.0	2.5	15.0
TOTAL	19.9	31.1	37.5	31.4	29.5	150.0

Budget (continued):

	Dollars in Millions					
	1975	1976	1977	1978	1979	5 Yr. Total
Improved Management						
Energy Data Base and System Modeling	3	3	4	3	3	16
Technology Assessment of Emerging Energy Systems	2	2	4	4	2	14
Evaluation Criteria for Energy Systems	2	2	1	1	1	7
Systematic Management Analysis of Alternative Energy Futures	3	5	5	5	5	23
TOTAL	10	12	14	13	11	60

B. INCREASED EFFICIENCY $1440M

Program Goals:

1. High-Temperature Gas Turbine $315M

To conserve energy fuels by developing high-temperature turbine systems that will result in increased efficiency of energy conversion.

2. Advanced Cycles, Fuel Cells, and Other $210M

To conserve energy fuels by developing more efficient methods for converting fuels to useful energy (other than through high-temperature gas turbine systems).

3. Advanced Automotive Propulsion $300M

To conserve energy and energy fuels by developing more efficient propulsion systems for automotive units.

4. Rail, Bus, Ship, and Air Systems $205M

To conserve energy by developing more efficient propulsion systems and increasing the efficiency of use patterns of air, rail, bus, and ship systems.

5. Energy and Fuel Transmission, Distribution and Storage $200M

To conserve energy by developing more efficient and reliable means of transmitting, distributing, and storing energy and energy fuels to meet the demand sector of the future in a safe, environmentally acceptable way.

FY 75-79 Program Objectives:

1. **High-Temperature Gas Turbines**

   a. To increase the overall efficiency and reliability of power generation and space heating systems by developing efficient high-temperature gas-turbine systems.
   b. To develop a direct cycle gas turbine for use with the high temperature gas reactor (HTGR).

2. **Advanced Cycles, Fuel Cells, and Other**

   a. To increase the overall efficiency and reliability of power generation by developing potassium-vapor topping and magnetohydrodynamic (MHD) conversion systems.
   b. To develop efficient and economical fuel cells for centralized and decentralized power generation.
   c. To develop systems for the economical conversion of wastes to power.
   d. To investigate, evaluate, and develop new concepts for efficient energy conversion.
   e. To evolve the basic constituent technologies that enable the substantial improvement of various power systems or that make feasible entirely new concepts for power generation.

3. **Advanced Automotive Propulsion**

   a. To improve the energy consumption efficiency of existing propulsion systems for autos and trucks and demonstrate new energy conservative vehicle systems.
   b. To explore and develop systems to use alternative fuels as substitutes for fuels derived from crude oil.

4. **Rail, Bus, Ship, and Air Systems**

   a. To conserve energy by improving systems capability to integrate mass transit systems.
   b. To develop design and engineering improvements to increase energy efficiency of ships.
   c. To improve efficiency of energy use by air transportation systems.

5. **Energy and Fuel Transmission, Distribution and Storage**

   a. To develop new or improved technology for a-c and d-c bulk power transmission systems that will provide the capability to double the present capacity (with further eventual increase to 4 to 10 times

present capacity) economically and without environmental degradation.

b. To develop underground transmission systems capable of matching future overhead systems in both power capacity and voltage with as low a cost differential between overhead and underground as possible.
c. To improve distribution system efficiency and reliability through advanced systems security/control methods and equipment.
d. To develop efficient and environmentally acceptable methods of storing energy for use during peak energy demand periods.
e. To develop advanced ship concepts for the transportation of fuels with improved throughput and efficiency and with improved environmental and safety controls.

Contributions to the Energy System If Success Is Achieved:

1. **High-Temperature Gas Turbines**

Energy savings in the year 2000 will amount to 2 x 10^{15} BTU, if high temperature gas turbines can be developed. Such turbines used in conjunction with ordinary steam cycle converters could raise the conversion efficiency of central station power plants to 50% or greater.

High-temperature gas turbines directly coupled to heating system burners could produce electric power and reject the waste heat for space heating purposes. The electric power generated would be a bonus not obtained in current heating systems. Some 2 x 10^{15} BTU per year could be saved this way by 2000. A direct-cycle gas turbine operating from the helium coolant from the HTGR will reduce efficiency losses that are expected if heat exchange to a second fluid is effected.

2. **Advanced Cycles, Fuel Cells, and Other**

Potassium topping cycles would conserve 1 x 10^{15} BTU per year by 2000. MHD used in a topping-cycle mode would effect similar savings.

Conversion systems using wastes as fuels have an unknown effect on the energy system but represent a major potential in solving municipal (and other) waste disposal problems.

Fuels cells could be used for decentralized conversion of fuels (e.g., natural gas) to electric power in homes or buildings or used to replace peak power generating systems at decentralized locations.

3. **Advanced Automotive Propulsion**

The proposed transportation energy research and development program will reduce transportation dependence on crude oil by 22% in the year 1985,

by 55% in the year 2000, and up to 100% after the year 2000. The proposed program for auto/trucks will result in a projected savings of approximately 1 billion barrels of oil per year by 1985 and 3 billion barrels per year by 2000.

4. Rail, Bus, Ship, and Air Systems

Information will be developed which could result in operational economics of aircraft to accomplish a 15% reduction in fuel use by 1985. The propulsion segment of the program provides means for reducing aircraft fuel requirements in the mid-1980's and beyond by major improvements in engine technology. Savings on the order of 30% or more by 2000 appear to be feasible; the proposed program will initiate the research and development effort required. The successful completion of research and demonstration projects directed toward a near-term reduction in transportation petroleum consumption by means of shifts to the energy conservative bus and rail modes of transportation could result in reducing the total projected transportation energy consumption by 3% in 1985 (0.15 billion barrels per year) and 5.8% in the year 2000 (0.36 billion barrels per year). With successful research and development, potential power savings of 15% can be made in the operation of ships.

5. Energy and Fuel Transmission, Distribution and Storage

Current technology applied to the projected need for electrical power in 1985 and 2000 would result in a doubling and quadrupling, respectively, of power lines and auxiliary facilities. The research and development objectives, if attained, would allow the transmission and distribution of the power with fewer high-capacity lines and result in underground transmission of much of the increased supply. Storage systems using batteries, electromagnetic, or mechanical devices would reduce requirements for peak load generation equipment that are inherently less efficient and make no use of the excess base load capacity during off-peak hours.

Liquefied natural gas tankers operating today lose up to 10% of their capacity through evaporation and represent significant safety hazards both on the seas and in port. Research and development would increase efficiency and mitigate the dangers. New ship concepts such as submarine tankers and extremely large barge-tankers would allow the shipment of energy fuels from arctic regions, lower costs for bulk shipment, and obviate requirements for deep-water ports for deep-draught tankers.

Program Plan:

1. High-Temperature Gas Turbine

An open-cycle high-temperature gas turbine will be developed to the point of constructing and operatirg a combined cycle 100-MW

demonstration power plant by 1979. A variety of fuel sources must be tested for compatibility. Catalytic combustion processes, water cooling techniques, and the application of ceramic materials for blades will be included in the development program.

A high-temperature gas turbine whose exhaust is used for space heating will be developed. A 2 to 3-MW power plant demonstration unit will be constructed and tested. Following tests, several such units will be used by the Department of Housing and Urban Development for demonstration in model energy conserving housing developments.

A 750-MW(e) helium direct-cycle gas turbine facility will be constructed to develop a turbine for use with the HTGR.

2. **Advanced Cycles, Fuel Cells, and Other**

A preliminary design and detailed economic assessment of a 1000-MW power plant using a potassium topping cycle will define program specifications. Based on these specifications, development will proceed to include design, construction, and operation of a pilot 30-MW potassium vapor topping cycle unit by 1979.

The MHD program will accelerate the development of the open cycle, liquid-metal closed cycle, and closed-cycle plasma concepts. All three program elements will address materials questions, systems analysis, and component design.

The program directed toward the use of wastes as fuels includes systems studies and prototype equipment development and testing for combustion, biochemical conversion and pyrolysis, and combusting wastes for power generation and auxiliary emission control technology development. Six incinerator-boiler pilot plants would be constructed or modified and operated.

Fuel cell development would be extended substantially to produce pilot and demonstration plants for acid hydrogen, methyl alcohol molten carbonate, alkaline hydrogen and high-temperature (1000°C) solid electrolyte type cells. Both centralized and decentralized applications would be studied. Pilot plants 10 kW or larger are planned.

Higher conversion efficiencies may be realized by utilizing advanced concepts such as Feher (CO_2) cycles, thermionics, or thermogalvanic cells. Applied research to test these concepts is planned in the FY 1975-1979 period.

A vigorous program of supporting research and development is necessary to augment the above program. Emphasis will be on metals and ceramics research for high-temperature application, thermodynamics, and catalysis.

3. Advanced Automotive Propulsion

Significant short-term impact can be achieved by conducting a program of research, development, and demonstration to provide a factual data base for a regulatory program aimed at reducing automotive petroleum consumption.

Assessment studies will be conducted to define the fuel economy improvements achievable with state-of-the-art technology and with new improved technology. Results will be disseminated, and development of the new technology will be initiated. Demonstrations of fuel economy improvements achievable with this technology will begin.

Several propulsion and vehicle systems will be evaluated, two of which will be brought to the engineering development phase. Preliminary battery design for a moderate performance electric car will be completed in FY 1977, and prototype motors, controls and power conditioning will be demonstrated in FY 1979. Studies will continue on the technical and economic feasibility of using fuels derived from domestic nonpetroleum energy resources for automotive transportation.

4. Air, Rail, Bus, and Ship Systems

Significant short-term impact can be achieved also by conducting a program of research, development, and demonstration to provide a factual data base for a regulatory program aimed at reducing aircraft petroleum consumption. Studies will be conducted to provide the technical basis for operational measures which will reduce near-term fuel savings on current aircraft.

Work will be done to provide the technical information required by developers of synthetic hydrocarbon fuels for assurance that the fuels, when produced, will be suitable for current aircraft propulsion utilization and to devise and demonstrate the technology for alternate fuels handling at airports.

Work will be directed toward technology for improving fuel economy of existing engine types, for development of advanced fuel-conservation gas turbine engines, low-drag aircraft, and for adaptation of aircraft gas turbine engines to the use of alternate fuels.

Some effort will be expended to determine the technical and economic feasibility and to generate critical long-lead technology for air-cushion vehicles, lighter-than-air vehicles, and very large slow airplanes as energy-conservative alternatives to conventional aircraft for large cargo shipment.

New rail and bus technology developed by industry and the Federal Government is proposed to be brought to bear in new-initiative demonstrations. Major efforts for integrated bus transit systems are proposed for a city with a population under 1,000,000 to be followed by a larger city of about 2,000,000. Computer aided information dissemination systems will be demonstrated.

Work will be done to improve those aspects of ship design and operation that impact on fuel consumption (hull shape, propeller design, and anti-fouling techniques). Work will continue on nuclear propulsion for ships, at least through the exploratory development phase.

5. Energy and Fuel Transmission, Distribution and Storage

Development objectives during the FY 1975-1979 period include prototype 1100-kV a-c overhead transmission lines and a 100-MW d-c terminal demonstration project. Four improved types of underground cables will be developed and completed for commercial use, and model tests of superconducting cables will be conducted.

A 10-MWH pilot model of a sodium-sulfur or lithium-sulfur battery will be built and a superconducting energy storage magnet will be developed to the prototype design stage. Engineering development of a flywheel facility will be completed.

Concept designs of surface and underwater ocean tankers, especially adapted for arctic service, will be completed. Advanced designs for LNG tankers with greater efficiency and safety will be developed. Computer controlled sailing ships will be studied and scale models tested.

Supporting Evidence:

1. High-Temperature Gas Turbines

Although gas turbines are now used widely, the use of gas turbines in sizes required for central station base load power production is rare, and lifetimes are too short to justify economic operation. Conservative management policies within the utility industry retards acceptance of this innovation and market formation. Large scale demonstration is necessary to encourage adaption to commercial use. Research and development partnership with industry should be forthcoming.

2. Advanced Cycles, Fuel Cells, and Other

Potassium topping cycles are technically feasible, but several materials problems must be overcome before systems can be built that will operate for lifetimes required in central power stations. Progress on MHD systems is also materials dependent.

Wastes used as fuel is also a technically feasible concept, but the economics of such an industry will depend largely on total system design to include recovery of other valuable resources (e.g., metals). Cost analyses and total system demonstration are required for proof of the concepts.

Fuel cells work today, but capital costs are high. Their ultimate application may depend on plentiful supplies of natural or synthetic gas or hydrogen. Less expensive catalysts and mass production methods may hold the key to reducing high initial costs.

Advanced concepts such as Feher (CO_2) cycles, thermionics, and thermogalvanic conversion are still in the early stages of technical evaluation.Theoretical efficiencies are high (60% or greater) but much bench scale testing is required to prove concepts for eventual economic application.

3. Advanced Automotive Propulsion

There seems to be no insurmountable manpower or capital availability problems in developing greater efficiency in automotive engine design and operation. Certain engines including the Rankine and Stirling cycle engines are inherently more efficient than the present internal combustion engine, and it should be possible to adapt one of these for future use on automotive systems.

Widespread application of new designs or concepts must be preceded by industrial willingness to change long standing methods of operation or governmental sanctions.

4. Air, Rail, Bus, and Ship Systems

Aircraft turbines are relatively efficient at present, but large savings in fuel can be achieved through improvements in the national air use system. Similarly, it is imperative that much thought be given to shifting transport modes from relatively inefficient automotive and air systems to the more inherently efficient rail system. The use of nonpetroleum fuels for aircraft systems would effect a significant savings in crude-oil requirements.

While ocean transport is still the most economical form of cargo shipment, there remain significant impediments to greater efficiency, specifically in drag reduction.

Nuclear ships exist today, but the economics of wider commercial use must be studied further, demonstrated, and safety aspects proven.

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5. Energy and Fuel Transmission, Distribution and Storage

Cost restrictions inherent in underground transmission systems and superconducting magnets may require Federal tax incentives initially. No other restrictions in development or operating skills, material, or equipment are preemptive. Transmission systems with larger capacity are technically feasible, but economic criteria demand further development for cost-reduction purposes.

Storage systems must show economic advantages over peak-load generating costs that are now incurred.

The potential for finding and exploiting significant quantities of fuels in the arctic regions demands that we investigate appropriate means for economic and safe transport of those fuels to U.S. markets.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
High-Temperature Gas Turbines ..	18.3	66.8	79.3	76.8	73.8	315.0
Other						
Potassium Topping Cycle	7.0	14.5	26.0	20.5	22.0	90.0
Wastes as Fuel	1.5	2.6	2.3	1.9	1.7	10.0
Fuel Cells	5.5	9.5	17.0	21.0	27.0	80.0
Advanced Concept	2.0	2.0	2.0	2.0	2.0	10.0
Enabling Technology	2.0	3.0	5.0	5.0	5.0	20.0
Subtotal	18.0	31.6	52.3	50.4	57.7	210.0
Advanced Automotive Propulsion .	53.0	59.0	59.0	71.0	58.0	300.0
Air, Rail, Bus, and Ship Systems						
Air	10.0	19.0	26.0	30.0	54.0	139.0
Rail & Bus	4.0	5.3	6.3	9.0	10.4	35.0
Ship	6.0	8.2	4.2	5.8	6.8	31.0
Subtotal	20.0	32.5	36.5	44.8	71.2	205.0

Budget (continued):

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Energy & Fuel Transportation Distribution & Storage						
Overhead T&D	8.1	7.4	7.4	7.4	9.4	39.7
Underground T&D	5.3	7.5	7.8	10.0	12.0	42.6
Storage	4.2	7.0	11.7	12.5	15.5	50.9
Systems Research	2.4	3.6	4.0	2.9	3.9	16.8
Ship Delivery System	7.0	8.0	9.0	12.0	14.0	50.0
Subtotal	27.0	33.5	39.9	44.8	54.8	200.0

TASK 2—INCREASED PRODUCTION OF OIL AND GAS

A. PRODUCTION $310M

Program Goals:

To increase the production of oil and gas by developing and demonstrating new technologies and extending current technologies that will result in rapid and economic in situ recovery of domestic resources.

FY 75-79 Program Objectives:

1. To increase the production of oil in operating fields by developing and demonstrating methods for secondary and tertiary recovery of residual reserves.
2. To increase the production of oil and natural gas by developing and demonstrating methods for stimulating flow in low permeability reservoirs.
3. To increase the production of synthetic petroleum from oil shale by developing and demonstrating methods for processing oil shale in situ to recover liquid products.
4. To increase the production of oil and gas by developing and demonstrating equipment design and methods of operation that will result in more economical drilling operations, environmentally sound practices, and a concomitant rise in find rates and the exploitation of deeper reservoirs.

Contributions to the Energy System If Success Is Achieved:

It is estimated that secondary and tertiary recovery could increase the production in operating fields by 260 million barrels per year by 1985. This could also result in the production of an additional 700 billion cubic feet of associated natural gas per year by that time. Improved methods for stimulating the flow of oil and natural gas in low permeability reservoirs could result in recovery of an additional 70 million barrels of oil and 2.6 trillion cubic feet of natural gas per year by 1985. Sucessful development of the technology for processing oil shale in situ could result in the production of 200 million barrels of synthetic oil per year by 1985. The development of equipment and procedures for faster, deeper, and more economical drilling could result in the discovery and recovery of 500 million barrels of oil and 2.5 trillion cubic feet of natural gas per year by 1985. Better drilling and operating policies could reduce the incidence of oil spillage and make offshore operations more environmentally acceptable.

Program Plan:

Combinations of four methods for secondary and tertiary recovery of oil will be tested in approximately 20 experiments that will include some 15 reservoir types. These experiments will determine optimum methods applicable to particular reservoirs.

Seven experiments are planned in three different reservoirs to determine the potential of massive hydraulic fracturing and chemical explosive

fracturing for stimulation of low permeability formations. One further nuclear stimulation demonstration is also planned. The program is designed to determine which stimulation technique or combination of techniques is most suitable for given reservoir characteristics.

In situ retorting of oil shale will be tested in the Rocky Mountain basins using a combination of several different fracturing techniques and retorting conditions. The recovery rates for each combination and the control problems encountered will be studied to determine optimum technical design.

Development will be continued on jet drilling techniques and equipment and spark cavitation drilling concepts. Field tests on prototype equipment are planned to determine what improvements are possible in rate of penetration and capabilities in differing rock formations. Better control devices and practices will be tested to show potentials for reducing oil spillage, and oil-spill cleanup methods will be assessed.

Supporting Evidence:

Oil company research on secondary and tertiary recovery has been significant (~$30M/year). The lack of data exchange has inhibited widespread application of techniques or development of techniques with more general application. A Federal effort should be capable of drawing the technology base together and effecting technology transfer.

Nuclear stimulation of tight gas reservoirs has been successfully demonstrated. Further testing is required to demonstrate economics and to enhance efficiency. Explosive and hydraulic fracturing is effective in certain reservoirs, but massive techniques are theoretically indicated for effectiveness in the tight reservoirs.

In situ oil-shale retorting has been successfully demonstrated on a pilot scale.

Faster experimental drilling techniques now exist. Improvements are required in control technology, downhole equipment developments, and in extending operating lifetimes. "Blowout" control and oil-spill cleanup development are continuing activities of the oil industry but require greater emphasis to support enlarged offshore drilling activities.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Secondary and Tertiary Recovery (fluid injection)	10.7	22.4	20.5	12.0	4.8	70.4
Stimulation (conventional and nuclear)	9.1	31.2	23.2	16.6	16.2	96.3
Oil Shale In Situ (conventional and nuclear)	9.3	30.0	30.7	29.6	28.2	127.8
Advanced Drilling	2.6	5.5	5.1	1.3	1.0	15.5
TOTAL	31.7	89.1	79.5	59.5	50.2	310.0

B. RESOURCE ASSESSMENT $150M

Program Goals:

To support the increased production of oil and gas, the substitution of coal for oil and gas, and the production of nuclear fuels by enlarging the qualitative and quantitative inventory of domestic resources through exploratory techniques and new equipment and methods research.

FY 75-79 Program Objectives:

1. To improve as rapidly as possible the knowledge level of domestic resources and economically available reserves of oil and gas, both onshore and offshore.
2. To improve as rapidly as possible the knowledge level of domestic resources and economically available reserves of uranium and thorium.
3. To assess the Nation's coal resources in terms of quality, regional distribution, and recoverability.
4. To improve the information base on the distribution and quality of oil shales and tar sands.
5. To maintain an overview of the quantities and availability of nonenergy mineral resources essential to the energy-producing system.
6. To improve general exploration theory and technology.

Contributions to the Energy System If Success Is Achieved:

This research and development will lead not only to knowledge of new resources but also to better ability to judge the quality of existing resources. In coal especially this will lead to the ability to do better other research on combustion (which is related to the byproduct content of coal types). In the oil-shale area it will also better define sites for in situ plants.

Program Plan:

Program activities would comprise 70% research in preexploration assessment technology and 30% analysis and research in exploration technology for onshore resources; and 90% exploration and 10% analysis and research for offshore resources.

Preexploration assessment to include the use of novel techniques will enlarge the data base necessary to analyze regions where resources are expected. The analysis effort will consist of accumulating, collating, and assessing data to improve methods of determining resource availability, both quantitatively and qualitatively.

The research effort is largely directed at the development of new exploration and analytic tools needed to locate and assess new reserves, including analogic digital modeling of energy resource deposits and identification of sedimentary process indicators for exploratory work.

A viable technology transfer program is required to disseminate findings to industrial users who would conduct most actual exploration efforts.

Supporting Evidence:

Federal responsibility for the development of natural resources cannot be properly discharged without knowledge of the resource base. Determination of viable energy options, resource development priorities, public land lease programs, prices, and subsidies should be based on reliable evidence of resource availability.

The current Federal research and development resource assessment program is not considered adequate to support a vigorous expansion in the use of domestic resources. Rational development at an increased pace requires greater knowledge than now exists if the highest payoff at least cost and environmental risk is to be ensured.

Industry welcomes and relies on Federal data and analyses to design their exploration and exploitation programs. Further, such data and analyses will provide a more rational basis for the development of national energy policies and energy research and development programs.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Petroleum and Natural Gas	6.7	8.3	13.0	20.0	22.0	70.0
Uranium and Thorium	6.3	6.7	8.0	9.0	10.0	40.0
Coal	3.0	4.0	4.5	4.5	4.0	20.0
Oil Shale	1.0	1.0	1.0	1.0	1.0	5.0
Non-Fuel Resources	1.0	1.0	1.0	1.0	1.0	5.0
General Exploration Technology	2.0	2.0	2.0	2.0	2.0	10.0
TOTAL	20.0	23.0	29.5	37.5	40.0	150.0

TASK 3—SUBSTITUTE COAL FOR OIL AND GAS

Program Goal:

1. **Mining** $325M

To develop and demonstrate more productive, safe, low environmental impact coal mining technology to the point where the mining industry can rapidly incorporate this technology in greatly expanded future operations.

2. **Direct Combustion** $200M

To substitute coal for oil and gas by developing coal-fired boilers for electric power generation which have improved thermal conversion efficiency, reduced costs, and acceptable environmental impact.

3. **Synthetic Fuels** $1270M

To substitute coal for oil and gas by developing the technology for converting coal to clean liquid and gaseous fuels.

4. **Common Technology** $380M

To provide the necessary supporting research and development to achieve the other coal objectives and to develop the technology necessary for reducing, to acceptable levels, the environmental impact of commercial scale coal processing, transportation, conversion, and combustion operations.

FY 1975-79 Program Objectives:

1. **Mining**

(a) To develop and demonstrate surface coal mining systems featuring integrated extraction and reclamation processes that meet environmental, social, and economic constraints.
(b) To develop underground coal mining systems that increase average productivity to 30 tons/man shift with as complete extraction as possible in a manner that ensures safety and environmental protection.
(c) To develop systems for mining oil shale in an environmentally safe and productive manner.

2. **Direct Combustion**

To complete pilot-scale tests of four methods of clean combustion of coal and to build and operate one pressurized fluidized-bed boiler system.

3. **Synthetic Fuels**

(a) To investigate several processes for converting coal to pipeline-

quality gas and to build and operate a demonstration coal gasification plant.

(b) To build and operate three to five pilot plants and two combined-cycle demonstration plants to test four processes for converting coal to gas of a low BTU content.

(c) To investigate several processes for converting coal to liquid boiler and distillate fuels, select three or more of these for further testing in pilot plants, and design one demonstration plant.

(d) To support the construction of two commercial-scale plants incorporating state-of-the-art processes and techniques for producing oil and gas from coal and to measure, monitor, and evaluate the operation of these plants.

4. **Common Technology**

(a) To obtain data through laboratory research on materials and component development for various coal conversion processes.

(b) To provide exploratory data for development of new processes.

(c) To develop an economical method of removing sulfur dioxide from flue gas.

(d) To reduce impurity and pollutant discharges resulting from the combustion of coal.

(e) To improve the technology for impurity removal from coal by physical and chemical treatment.

(f) To ensure the environmental acceptability of commercial scale processes of converting coal to gas and to liquids.

(g) To develop economical methods of disposing of wastes resulting from the use of coal.

(h) To investigate the feasibility of converting coal to gas in situ.

Contributions to the Energy System If Success Is Achieved:

1. **Mining**

To attain energy self-sufficiency, U.S. coal mining capability will have to at least triple in this century. In the near-term over 600 million tons/year of additional coal production capacity will be required by 1985.

2. **Direct Combustion**

When fluidized-bed boilers are developed, they will capture at least 25% of the market for new coal boilers. This implementation rate would result in 300 MW (or 0.2×10^{15} BTU fuel input) installed capacity in 1985 and 40,000 MW (2.2×10^{15} BTU) in the year 2000.

3. **Synthetic Fuels**

As a result of the proposed program, full-scale (250 million cubic feet/day) high-BTU gasification plants could be operating by 1980. Present estimates point to 1.2 trillion cubic feet/year of high-BTU natural gas from coal by 1985 and 3 trillion cubic feet/year by 1990.

Commercial production of low-BTU gas is expected to proceed at a rapid pace after successful demonstration, and the estimated benefits of this program to the Nation are:

	1985	2000
No. plants	10 commercial plants	210 commercial plants
Electric power	32.9×10^6 MWH(e)	1150×10^6 MWH(e)
Q energy released for priority uses	0.28×10^{15} BTU	9.8×10^{15} BTU
Q saved by high efficiency	0.014×10^{15} BTU	$0.49\text{-}0.9 \times 10^{15}$ BTU

Coal liquefaction could produce 250,000 barrels/day of liquid fuels in 1985. By the year 2000 it could produce 3 to 4 million barrels/day of liquid fuels and 1.5 trillion cubic feet of by-product synthetic pipeline gas.

4. Common Technology

Flue-gas cleaning and fuel cleaning could ultimately impact upon the entire industrial, residential/commercial, and utility market. Flue-gas environmental control capabilities could be achieved on 10 to 16×10^{15} BTU of generating capacity by 1985 and 20 to 40×10^{15} BTU of generating capacity by 2000. By the year 2000, yields of 2 to 6×10^{15} BTU/year of clean usable energy could be obtained by fuel cleaning. Ultimate application of pollution control technologies will allow achievement of air quality criteria from fuel combustion and, thus, continued use of existing domestic coal as fuel.

In situ gasification of coal could produce large quantities of pipeline-quality gas without recourse to mining and the disposal of processing-plant wastes.

Program Plan:

1. Mining

The surface coal mining program will develop and demonstrate mining and reclamation systems and equipment that would permit surface mining in the western and Appalachian coal fields at minimum cost and environmental impact. Particular attention will be paid to demonstration projects to assess the efficacy of the best present technology and identify and resolve indicated deficiencies.

The underground coal mining program will develop and conduct demonstrations of equipment systems for high-speed horizontal mine development, improved longwall mining, continuous materials handling systems, improved roof control systems, commercial extraction of methane from virgin coal and gob areas, and novel mining concepts. Technology for environmental protection associated with underground mining, including

control of subsidence phenomona, control of chemical mine drainage effluents, and acceptable methods of waste disposal will be demonstrated.

The shale mining program is directed toward heading off immediate critical problems in oil-shale mining in the Piceance River basin, Colorado, where mining may be greatly increased soon. Principal emphasis will be on: (1) systems analysis effort to adapt surface mining technology to the unique problems of large-scale oil-shale extraction; (2) the development of basic structural parameters for the design of underground mines; (3) investigation of occurrence and movement of ground water in the oil-shale strata; and (4) investigation of environmentally acceptable means of restoring surface-mined terrain to as good or better than original condition. New facilities will include a multipurpose prototype mine shaft to provide access to the deeper oil-shale sections.

2. Direct Combustion

Several clean combustion processes will be developed and tested in pilot plants. These include: (1) the pressurized boiler concept, in which the fluidized bed contains the heat transfer surface and the hot pressurized off-gases are expanded through a gas turbine; (2) the atmospheric pressure concept; and (3) the direct turbine drive concept. A mathematical model describing the fluidized-bed combustion process will also be developed. Each of the three variations will be tested in a separate intermediate sized plant (30 to 50 MW). One full-scale demonstration plant will be built.

3. Synthetic Fuels

The proposed plant for high-BTU gasification involves the acceleration of the present program being conducted under the joint direction of the Office of Coal Research and the American Gas Association, and the present Bureau of Mines program, as well as a program of supporting research and development for equipment/materials research and development and for basic studies of gasification chemistry. This plan includes the operation of the Hygas process pilot plant and the CO_2-Acceptor process pilot plant, completion of the construction and operation of pilot plants for the Synthane and Bi-Gas processes, and the construction and operation of one 80 million cubic feet/day demonstration plant.

The low-BTU gasification program includes the construction of the entrained bed gasifier type pilot plant [30 MW(e) to 50 MW(e)] within an existing utility and consisting of a gasifier, a gas turbine, a waste heat boiler, and a steam turbine. Cycle efficiency is estimated to be over 40% with initial operation expected in 1977. A fluidized-bed gasifier (pressure type) pilot plant [30 MW(e) to 50 MW(e)] will also be constructed. Initial operation is planned for 1978. A slurry fired pilot scale plant is planned for initial operation in 1976 or 1977. This is a pumpable coal/water high-temperature slurry feed system with high-temperature clean up of sulfur and particulates in a single compact vessel. In addition, three to five of the numerous new concepts for low-BTU gasification will be tested at the pilot scale.

Supporting development, including hot gas cleanup projects, will be carried out. Approximately two-thirds of the funding will be for the two demonstration projects and one-third for the smaller scale projects.

The coal liquefaction program consists of a series of interrelated, mutually supporting projects that will investigate alternate methods to liquefy coal. The work includes appropriate pilot plant, process plant, and laboratory-scale experiments. The end result is expected to be a demonstration plant test center where synergistic processes can be tested singly and in combination to show both technical feasibility and economic viability. A solvent refined coal (SRC) pilot plant will be completed and put in operation.

In addition, it is planned to support industry initiatives in funding the construction of two commercial scale plants to produce synthetic fuels from coal using state-of-the-art processes and technology. The operation of these plants will be monitored and evaluated to determine engineering improvements needed to upgrade processes and to assess the potential for further research and development in coal conversion processes.

4. Common Technology

Although the basic feasibility of producing gas and oil from coal and shale has already been demonstrated, ultimate economic practicality of these energy sources may depend either on the development of new procedures for at least part of these processes or on the gradual improvement of existing processes, materials, and equipment. Specific areas where technology development and support research are needed include: equipment development, materials improvements, investigation of catalysts and chemical kinetics for conversion processes, process development, and hydrogen production.

Methods for ensuring the environmentally acceptable combustion and utilization of domestic fuels will be reduced to commercial practice. Processes will be developed and demonstrated for improved control of particulate, sulfur dioxide, and hazardous pollutant emissions from combustion flue gases. Methods for environmentally sound coal conversion will be reduced to commercial practice. Technology for the physical and chemical separation of pollutant-forming constituents from coal will be demonstrated. Methods for ensuring the environmental integrity of major conversion technologies will be developed, and conversion process by-product recovery/utilization will be developed.

Concepts for the in situ gasification of coal will be evaluated and tested on a small scale to determine the potential for producing synthetic gas without recourse to mining and surface processing, thus reducing the overall environmental impact.

Supporting Evidence:

1. Mining

A resource base of necessary research skills exists within the Government owing to existing programs in the Bureau of Mines and Geological Survey. Lead time exists in which to develop skilled manpower for implementation of research results. Union resistance to improved mining systems can be expected to be minimal because of historical union positions, benefits to the miners, and the importance of the energy crisis. The importance of the crisis will also affect potentially inhibiting legislative restrictions. As the economic incentive (a long-term requirement for coal) increases, the coal industry will be able to adapt its financial and management structure to the necessary capital expenditures for innovative mining techniques. The same should hold true for the mining equipment industry.

2. Direct Combustion

Much of the technology in this area is available on a laboratory-scale basis. Further engineering and development is required to demonstrate its use on a commercial scale.

3. Synthetic Fuels

Several methods are known for producing pipeline quality and low-BTU gas from coal on a laboratory scale. The program described will allow further larger scale testing of these processes and the completion of a demonstration plant. The coal liquefaction program is based on technology that has been carried through small scale equipment and is supported by ongoing pilot plant projects. The primary risk involves scale-up, which means that plant outputs cannot be guaranteed but product quality can. The primary barrier to commercial acceptance is industrial fear of the magnitude of the investment in commercial plants. By underwriting the major risk, the Government will ensure the maximum rate of commercial adoption of these processes.

4. Common Technology

The various processes for burning and converting coal could not be pursued economically or rationally without parallel technology development and supporting research. Government funding of the pollution control area is required in view of the requirement for a cohesive, well-directed research and development program to support environmental quality control. Private industry cannot be relied upon to develop the broad research and development program that is needed.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	5 Yr. Total
Mining	45	57	64	77	82	325
Direct Combustion	30	35	40	44	51	200
Synthetic Fuels	240	287	264	254	225	1,270
Common Technology	90	72	66	72	80	380
TOTAL	405	451	434	447	438	2,175

TASK 4—VALIDATE THE NUCLEAR OPTION

A. HTGR, SAFETY, WASTE MANAGEMENT, ETC. $1245.7

Program Goal:

To guarantee the nuclear option by performing research and development that will enhance the safety, environmental acceptability, reliability, and economic viability of nuclear converter reactors.

FY 75-79 Program Objectives:

1. To develop an improved basis for assessing the performance of safety systems and to develop improved safety systems and surveillance instrumentation necessary to ensure the safe and reliable operation of nuclear power plants.
2. To develop the control technology necessary to reduce nuclear power industry effluents to the lowest practical levels and to develop to full scale use a safe and efficient means for disposing of wastes generated by the nuclear power industry.
3. To develop techniques to reduce the environmental impact of thermal discharges from power plants and to develop guidelines for more rapid and standardized procedures for selection and review of facility sites.
4. To develop more efficient methods for uranium isotope separation.
5. To conduct research and development needed to heighten assurance of safe, reliable operation of the HTGR.
6. To develop satisfactory fuel fabrication and reprocessing systems for thorium to be used in the HTGR.
7. To successfully demonstrate the Light Water Self-Sustaining Reactor.

Contributions to the Energy System If Success Is Achieved:

The program proposed will ensure that nuclear power plants are available to meet their planned share of the requirements imposed by the growth in demand over the next few decades. Nuclear reactors are now used to generate 5% of the Nation's electrical power. This fraction is expected to grow to about 23% by1980, 49% by 1990, and 60% by the year 2000.

The program is directed at ensuring that the technology and resources are provided at the appropriate times to meet these scheduled increases in the role of nuclear power. It is also directed at ensuring that current apprehensions about the safety of nuclear power are met by definitive research and development at an early time.

The HTGR and the light water self-sustaining reactor can more efficiently and economically utilize available uranium and thorium resources and reduce the uranium supply and separative work requirements per unit of power over plant life. This will make sizable contributions toward conserving resources.

Program Plan:

Theoretical and experimental investigations will be conducted to obtain more complete information as to component failure and accident probabilities for nuclear reactors. Practical experimental results will be derived from the Loss of Fluid Test Facility (LOFT). The investigations will yield additional data applicable to the design and engineering of safety features and the establishment of regulatory standards.

The design of an engineered waste storage facility will be completed and construction begun early in the five-year period. Studies will continue on disposal of long-lived radioactive wastes in geologic formations, and a pilot facility in bedded salt will be constructed. Ancillary solidification processes will be developed and tested. Development will continue, and pilot and demonstration plants will be constructed to reduce or eliminate krypton, tritium, and transuranic components from reactor and reprocessing effluents.

The concept of the dry cooling tower to replace wet cooling will be the subject of a joint government-industry technology demonstration in Wyoming. Results and other studies are expected to lead to the construction and operation of a larger scale test facility after 1980.

A significant effort will be directed towards enlarging the options for siting of nuclear facilities.

The search for more efficient processes for uranium enrichment will include development aimed at improving the gaseous diffusion process, the demonstration of commercial feasibility of the gas centrifuge process, and exploratory efforts to prove technical feasibility of isotope separation using lasers. The centrifuge test facility and ancillary facilities will be completed.

The base program for the High Temperature Gas Reactor (HTGR) will continue development of components and the review of safety features. The completion of research and development for ^{233}U-thorium utilization in the HTGR will include the completion and operation of reprocessing and refabricating pilot plants. Process demonstrations will open the path to using large resources of thorium in addition to ^{238}U.

An experimental core for a self-sustaining light water reactor using the ^{233}U-thorium fuel cycle will be tested in the AEC's Shippingport facility.

Supporting Evidence:

The current problem is to ensure timely licensing for construction and operation of nuclear power plants. One of the most important near-term objectives in this regard is to provide further assurance of the safety of the water and gas-cooled reactors. A considerable expansion of the reactor safety program needs to be undertaken to resolve questions raised. A related question concerns the management of highly radioactive wastes. A final solution to this problem is probably not necessary in the near-term period,

but study and evaluation of several potential waste-management methods can result in the selection of the most promising interim and permanent disposal techniques. There must be sufficient assurance given that the present and proposed handling of these wastes is not only satisfactory for the time being but also that the methods used will not place undue burdens on future generations.

One of the principal problems will be finding suitable locations for nuclear power plants. About 50 sites have now been approved, and it is becoming difficult in some cases to locate new sites that meet AEC site criteria for safety, are available, and can supply water coolant needs. A program on dry cooling towers is included that will increase site selection possibilities by reducing the need for access to large amounts of cooling water. The efficiency of the electrically generated power will be about 10% lower when dry cooling towers are used, but success of this technical innovation will overcome a difficult siting problem. Coupled with development of efficient cryogenic transmission methods, use of dry cooling towers will permit clustering of power reactors in parks in remote areas of the country, where population density is low and land costs are less significant.

A determined production program will be required to prevent shortages of nuclear fuel over the period before the breeder is heavily relied on. Additional uranium isotope separation capacity must be provided, with construction begun in the next two years if the enriched-uranium requirements of the 1980s are to be met. Planning now for improvements in isotope separation will ensure an adequate and low-cost capability.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Reactor Safety, Reliability, and Performance	90.6	125.6	143.0	170.5	189.5	719.2
Uranium Enrichment	64.2	54.8	57.4	58.4	59.4	294.2
High-Temperature Gas Reactor	40.0	44.7	24.2	26.9	28.0	163.8
Light-Water Self-Sustaining Reactor	21.4	17.7	9.8	9.8	9.8	68.5
TOTAL	216.2	242.8	234.4	265.6	286.7	1,245.7

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B. BREEDER REACTORS $2844.3

Program Goal:

To guarantee the nuclear option by developing a safe, environmentally acceptable, and economically successful breeder reactor that will draw upon domestic resources to provide an alternative long-term energy supply.

Program Objectives:

1. To develop the technology for and demonstrate the commercial feasibility of the liquid-metal fast breeder reactor (LMFBR).
2. To resolve the principal design and engineering problems of breeder reactors.
3. To develop the technology and methodology necessary to resolve safety questions affecting breeder reactor design.
4. To develop the necessary technology, methods, and procedures for handling and transporting plutonium.
5. To develop the technology for alternative breeder concepts including the gas-cooled fast reactor (GCFR) and the molten-salt breeder reactor (MSBR).
6. To develop advanced technology that would result in improved utilization of fissile resources.

Contributions to the Energy System If Success Is Achieved:

Liquid-metal fast breeder reactors will begin to assume an important role by the 1990s and will displace the light-water reactors as the principal nuclear plant by the early part of the next century. The breeder will be a more efficient electric generating plant thereby reducing thermal discharge to the environment and making more than 50 times greater utilization of uranium as a fuel source. By the year 2000, breeder reactors could be providing more than 250,000 MW(e) to our electrical system which would be the equivalent of about 13×10^{15} BTU thermal input. The gas-cooled fast reactor, although significantly behind the LMFBR in the developmental schedule, is a potential alternate to the LMFBR, and, if warranted, commercial operations could begin in the early 1990s.

Program Plan:

A comprehensive LMFBR technology effort is being conducted which includes support of: (1) the Fast Flux Test Facility required to conduct necessary fuels and materials testing programs and to demonstrate the performance of components selected for LMFBR use, and (2) an LMFBR demonstration plant program.

The LMFBR base program includes the continued development of fuels and investigation of their behavior properties under different conditions and with increased knowledge of the physics of breeder cores. Extensive work will be accomplished on the development of new components and the

analysis of the total reactor system incorporating selected designs. The base program also includes support for the operation of the Experimental Breeder Reactor and the Liquid Metal Engineering Center.

The engineering and safety aspects of the LMFBR program will include the construction and operation of an LMFBR engineering facility and advanced fuels laboratory, a steam generator test facility, a safety test facility, and a transient safety test facility. Technology development for handling, transporting, and containing plutonium will continue toward establishing the most desirable methods and procedures for adoption as standards and to resolve public questions regarding safety.

The program for the GCFR would provide required technology on fuel and reactor core development, physics, critical assembly tests, and safety analyses. In the MSBR area a fairly low level of effort will be expended to reevaluate the economics of this concept in light of recent information on fuel costs.

Advanced technology research is planned to develop new breeder fuels and materials that can increase the breeding ratios and power ratings and decrease the conservatism presently required in breeder designs. Also, neutron cross-section information needed for the design of fast and safe test reactors will be developed.

Supporting Evidence:

Adequacy of the manpower resources to meet the research and development program will have to be planned and programmed. There is presently a surplus of technical personnel suited to the research and development program. Beyond the first two years, additional trained technical manpower will be needed in scientific and engineering disciplines. These will have to come from the universities. The requirements are within the peak supply capability of engineering schools. Availability of manpower should be no problem if measures are taken to ensure vigor of the educational programs during the intervening period.

The availability of fuel should not present any problems but will require careful monitoring and management during the expansion of the first-generation non-breeding reactors and plutonium recycle employment. Operation of breeders in the early years will require additional uranium supplies, but, as newly-bred fuel becomes available, the demands for uranium will decline relative to continuation of a light-water reactor economy.

Capital costs of breeder reactors must be kept within a range that does not greatly exceed current reactor capital costs so that the fuel cost savings realized by breeders will be sufficient to permit total power generation costs to be lower for breeders.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Liquid Metal Fast Breeder	477.0	538.6	510.8	524.2	506.0	2,556.6
Gas Cooled Fast Breeder	17.0	23.0	29.0	33.0	38.0	140.0
Advanced Technology	21.5	24.5	30.5	34.0	37.2	147.7
TOTAL	515.5	586.1	570.3	591.2	581.2	2,844.3

TASK 5–EXPLOIT RENEWABLE ENERGY RESOURCES

A. FUSION $1450M

Program Goal:

To guarantee the nuclear option in the long range by developing the technology necessary for a fusion reactor to provide an inexhaustible, economically competitive, inherently safe, and environmentally acceptable supply of energy for domestic consumption.

Program Objectives:

1. To conduct theoretical, computational, and experimental studies in the body of knowledge that predicts the behavior of thermonuclear fusion experiments and the operating characteristics of fusion reactors.
2. To develop the technology necessary to perform fusion research.
3. To investigate, develop, and establish the feasibility of low-density closed (tokamak), high density closed (theta pinch), and open (mirror) magnetic confinement systems as a basis for practical fusion power generation.
4. To investigate, develop and establish the feasibility of laser fusion as a basis for practical fusion power generation.
5. To develop the engineering base, qualify materials, develop components, and conduct engineering studies necessary for the design, construction, and operation of prototype, demonstration, and commercial fusion power reactors.

Contributions to the Energy System If Success Is Achieved:

Fusion power systems are being developed primarily for electric power generation. Since the fuel supply for fusion is effectively infinite and its safety and enviromental features are very attractive, fusion power reactors could eventually become the primary source of electric power for the United States.

Because fusion power plants have the potential for high-temperature operation, they would be attractive for combining with industrial and municipal systems that could utilize the rejected heat. Examples of potential applications are numerous: basic manufacturing processes, water desalination, mineral and fossil fuel processing, space heating, and air conditioning, to name a few.

The commercialization of fusion power reactors would occur at the time of the successful operation of a fusion demonstration reactor. The goal of the projected program is to begin operation of this system by 1995.

Fusion reactors could be producing commercial electric power in the first decade of the next century and by 2020 could add 18×10^{15} BTU of energy input to our electrical system.

Program Plan:

The research subprogram will develop the knowledge to predict the performance of plasma-confinement experiments and the operating characteristics of fusion power reactors. In order to support the theoretical proving research, it will require extensive application of centralized dedicated computer facilities with an integrated network of remote job processing terminals. Theoretical studies of fusion-relevant plasmas in various confinement configurations are necessary to understand the equilibrium, stability, and transport properities of the plasmas. Experimental work on plasma production and heating, along with instrumentation development for plasma measurements, are among the earliest projects.

The development subprogram will provide the technology to plan or conduct plasma experiments. The magnetics subprogram requires very large, superconducting magnets to produce large volume, high magnetic fields to confine and stabilize fusion plasmas. The heating program will emphasize the development of neutral-beam injections for heating and/or fueling tokamak and mirror plasmas. The advanced design activity provides for the definition of conceptual designs and cost estimates for experiments prior to fabrication. Other development-activity objectives include energy storage devices, direct energy conversion, and components to support the various testing programs.

The present plan for plasma confinement systems development utilizes three principal magnetic confinement concepts. These are low-density closed systems (principally the tokamak), high-density closed systems (theta pinch), and open systems (magnetic mirror). The construction and operation of seven new facilities to test plasma shapes, neutral-beam heating, scaling, and improved confinement will be undertaken.

The technology subprogram deals with the problems that need to be solved for prototype, demonstration, and commercial fusion power reactors. Included are materials studies to determine the effect of 14-MeV neutrons and other high-energy particles on material performance, radiation environment simulation to create a simulated fusion reactor environment in which materials and components can be tested, and system studies to provide guidance. Other areas covered include major parts of the heat transfer system and the engineering base needed for the design and construction of such subsystems. Examples are neutronics, plasma engineering, coolants, blankets, shielding, tritium handling, and instrumentation.

The laser fusion subprogram will build on the theoretical base established in the military oriented laser fusion program. Projected achievement sequence is: (1) an experimental demonstration of significant thermonuclear burn; (2) the experimental demonstration of scientific breakeven for the laser fusion concept; and (3) the conduct of some reactor design studies throughout the program.

Supporting Evidence:

Although controlled thermonuclear fusion has yet to be technically demonstrated, recent program successes indicate high probabilities of success in being able to initiate and sustain fusion reactions. This factor warrants emphasis in fusion research and development.

Based on previous experience with nuclear reactors, it is clear that a savings of several years can be realized if reactor technology is developed now, assuming technical feasibility of the fusion reaction.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Research	43	52	47	70	44	256
Development	20	26	37	46	55	184
Confinement	59	113	122	153	194	641
Technology	13	39	55	69	83	259
Laser Fusion	10	20	25	25	30	110
TOTAL	145	250	286	363	406	1,450

B. SOLAR ENERGY $200M

Program Goal:

To exploit the sun and wind in order to provide a renewable, economically competitive, and environmentally acceptable energy supply for domestic consumption.

FY 75-79 Program Objectives:

1. To determine, through pilot applications, the effective use of solar thermal energy for heating and cooling of buildings.
2. To effectively use solar thermal energy for electric power generation through operation of a pilot plant [10 MW(e)].
3. To effectively use wind power for electric power generation by construction and operation of individual windmills [>100 kW(e)] and a windmill farm [10 MW(e)].
4. To determine the technical feasibility of producing electric power from ocean thermal gradients by laboratory-scale testing of prototypes and full-scale testing of necessary components.
5. To determine the capability to produce economically competitive photovoltaic cells by laboratory experimentation and development of mass production concepts.

6. To demonstrate, by pilot plant operation, the economic feasibility for conversion of wastes to fuels and the use of biota as fuel for power plant operation.

Contributions to the Energy System If Success Is Achieved:

Solar energy is virtually inexhaustible and is inherently clean. Successful research and development should ultimately lead to the capability to reduce the demand for fuels and power to heat and cool homes and commercial buildings by 30%.

Solar thermal, wind, ocean thermal gradients, and photovoltaic systems used to produce electric power could be used in decentralized or centralized applications depending on economies of scale. The potential exists for providing a large proportion of the electric power needs for the Nation from solar conversion stations without storage systems. However, the realization of the economical storage systems will substantially increase overall applications of solar energy.

Bioconversion is possible today,but it is not economically attractive. Converting wastes to fuels needs to be demonstrated on a large scale, and the use of biota as fuel is in the early study stages.

Program Plan:

The objective is to develop proof-of-concept experiments that will allow program management to concentrate at an early date on those technologies which show the most promise toward providing the Nation's energy requirements. It should be possible at the end of the five-year program to predict the complete range of the beneficial effects and the extent of application and utilization of solar energy.

Solar heating and cooling of buildings is entering the pilot plant stage. Applicability studies, design criteria development, and component testing will be conducted on a much enlarged scale. Operating pilot systems will be installed in single-family and multifamily dwellings, in agricultural buildings, and in commercial/industrial buildings. This development could provide the basis for an industry prepared to manufacture solar energy heating and cooling systems in large quantities.

Major emphasis in the solar thermal conversion area will be placed on the research and technology developments of key subsystems for the optical transmission/central receiver tower approach. Three system design efforts will be conducted in parallel. Design, hardware procurement and integration, and a testing program of a 10 MW(e) pilot plant will be achieved.

A series of experimental wind generator systems in increasing size and performance capability will be constructed and tested. The first unit of 100 kW(e) size will be built in the first year. Four additional advanced units will be developed and used in experimental operation in the following years. Multiunit wind generator systems making up a wind "farm" up to 10 MW(e) will be constructed late in the program period.

The ocean thermal energy conversion subprogram emphasis will be placed on the design, production, and testing of system components. Key elements that will require significant adaptation of existing technology include the heat exchanger, the deep-water pipe, and the overall plant structural design. A test facility is planned for construction.

The photovoltaic program will concentrate on the single-crystal silicon approach with only a modest research and development effort on alternative materials and concepts. Materials development and improved processes are necessary to permit automated production of cells to accomplish major cost reductions.

The construction and operation of a small-scale pilot plant involving the conversion of wastes into methane would lead to a 10 ton/day pilot plant later in the period. Laboratory-scale studies of methods for converting various organic materials to electric power, including research on biomass production, would be prominent in the program plant.

Supporting Evidence:

With the primary exception of photovoltaics, the development of practical systems will not require high technology. The research and development costs for solar energy should be very small in relation to the value of energy saved. Because solar energy systems are capital intensive and practical systems have not been fully developed, Federal involvement in the program is warranted.

Life-cycle costs for solar building heating and cooling look attractive, but capital investment is high and deters market formation. Component cost and reliability must be improved and has a high probability of success.

Solar thermal systems are currently projected to provide power at approximately double the cost of alternative nonsolar methods. New design concepts are being investigated for cost reduction purposes.

Wind energy systems can be built but must provide evidence of economic viability and aesthetic acceptance. Ocean thermal gradients can be exploited if appropriate thermodynamic cycle machinery can be engineered to operate in a hostile environment. Bioconversion systems are possible today, but many questions about degree of impact and economic viability must be answered by proof-of-concept experiments.

There is no potential impact from solar energy heating and cooling systems on the environment or safety. Problems associated with public and institutional acceptability will require resolution in the near-term.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Heating and Cooling of Buildings . .	12.8	13.6	10.7	6.5	6.4	50.0
Solar Thermal	5.0	7.0	7.5	8.5	7.5	35.5
Wind Energy	6.2	6.7	7.2	7.5	4.1	31.7
Ocean Thermal	1.9	3.5	4.5	7.2	9.5	26.6
Photovoltaic	4.2	5.6	7.0	8.0	11.0	35.8
Bioconversion	2.4	3.5	4.5	4.5	5.5	20.4
TOTAL	32.5	39.9	41.4	42.2	44.0	200.0

C. **Geothermal** $185M

Program Goal:

To exploit geothermal sources by developing and demonstrating the technology that would allow commercial production of electrical power and other energy uses in environmentally acceptable ways.

FY 75-79 Program Objectives:

1. To increase present knowledge of the location, nature, and extent of the Nation's geothermal energy resources.
2. To identify and resolve the environmental, legal, and institutional barriers to geothermal resource utilization.
3. To advance, through technology development, the operational efficacy and efficiency of relevant components, devices, and techniques as required to achieve practical geothermal resource utilization.
4. To accelerate, through demonstration plants, the commercial production of electricity from geothermal resources.

Contributions to the Energy System If Success Is Achieved:

The five-year effort will greatly enhance the industrial capability to locate and evaluate geothermal resources, to identify and solve the environmental problems associated with geothermal developments, to clarify institutional and legal issues involved in geothermal energy uilization, and to upgrade the existing technology available for geothermal development and utilization, including power generation and heat applications.

The present program is designed to stimulate the commercial production of at least 20,000 MW(e) by 1985 from various types of geothermal resources (equivalent to an oil consumption rate of approximately 0.7 million barrels of oil per day) plus important additional fuel savings through use of geothermal energy for such nonelectric purposes as space heating and air conditioning, extracting minerals, and desalinating brines. The corresponding goals for the years 2000 and 2020 are 80,000 MW(e) and 200,000 MW(e), which would save nearly 3 million and 6 million barrels of oil per day, respectively. The equivalent heat values for 1985, 2000, and 2020 are 1.5, 6.0, and 15×10^{15} BTU's.

Program Plan:

The five-year program is a coordinated effort toward meeting all objectives for four types of geothermal resources and preparing for prompt demonstration of energy production from two other types.

Each type of resource poses special problems in location and distribution, reservoir analysis, environmental hazards, energy conversion and utilization and in the severity of and solution time of technical questions involved in bringing the resource to on-line production. Each experimental facility will, therefore, be a flexible test bed for research and engineering development as well as for demonstrations of electrical generation and the other uses of geothermal heat. Throughout the program effective technology transfer will be encouraged by cooperative arrangements with industry, and special attention will be given to the institutional, legal, social, and environmental issues bearing on utilization of that particular type of resource.

Under this program plan, demonstration plants using four of the six advanced resource types will be completed and operated jointly with industry to obtain engineering and economic data. Two other resource types would be demonstrated soon after.

Resource Type	Demonstration
1. High-temperature (> 180°C) convective	
a. Low-salinity (20,000 ppm or less)	1978
b. High-salinity (over 100,000 ppm)	1979
2. Low-temperature (<180°C) convective	1979
3. Geopressured sedimentary basins	1979
4. Hot dry rock	1981
5. "Normal" geothermal gradients	1983

Supporting Evidence:

One geothermal resource type is presently being used to produce power in the U. S. – dry steam generating 400 MW(e) at The Geysers near Santa Rosa, California. Six other types – brines at high temperature and low salinity high temperature and high salinity, low temperature and low

salinity, and in geopressured reservoirs, plus dry hot rock at shallow depth and in deep, normal-gradient formations – are potentially available for economic energy recovery. The first of these is being utilized in several foreign installations.

Major technical problems to be solved are concerned with the handling of corrosion and toxic substances and the successful utilization of low-temperature fluids. Practical binary cycles that use low-temperature working fluids must also be developed.

Theory and engineering design are available to support further development in the use of several resource types, and experimentation and demonstration have begun for a few. What is required now is an effort to attempt successful demonstration of the concepts.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Resource Assessment and Exploration	9.7	10.5	10.0	10.0	9.0	49.2
Environmental, Legal, and Institutional Research	3.4	3.5	2.5	1.0	.5	10.9
Resource Utilization	16.9	17.5	18.3	14.4	11.0	78.6
Advanced Research And Technology	10.0	9.5	10.0	9.8	7.0	46.3
TOTAL	40.0	41.0	40.8	35.7	27.5	185.0

TASK 6—SUPPORTING PROGRAMS

A. ENVIRONMENTAL EFFECTS $650M

Program Goal:

To establish the capability to determine and control effectively the environmental and health insults from the energy system through development of a sound technical and scientific basis for ensuring protection of the total ecosystem.

Program Objectives:

1. To determine the nature of pollutants and the quantity in which they are produced and to devise means of identifying and measuring the pollutants.
2. To determine the means by which pollutants are injected into the environment, the means by which they are diffused, and the distribution of pollutants at their final point to rest.
3. To determine the health, welfare, social, and ecological effects of pollutants on man and on all aspects of his environment.
4. To develop standards and specifications that will lead to effective protection of the environment.

Contribution to the Energy System If Success Is Achieved:

Implementation of the environmental research program described will make a vital contribution to the national energy system in three critical areas (1) cost, (2) usability of domestic energy sources, and (3) timeliness in implementing energy system initiatives.

With respect to costs, at least $90 billion will be spent by the energy industries in the period 1971-1980 alone to meet established environmental requirements for the limits set on air and water pollutants. This amount of pollution control expenditure will add about 15% to the wholesale delivered national cost of energy over the same time period. By providing the technical and scientific environmental knowledge to be gained from this research and development program, it will be possible to develop and demonstrate environmental controls in conjunction with developing energy technology rather than having to rely on the costly retrofit programs exemplified by the current SO_x control program. It is estimated that the environmental cost to achieve the broad environmental objectives could in this manner be reduced to less than 10% of the wholesale delivered national costo of fuel.

The technological development and implementation of coal-based energy systems for near-term energy self-sufficiency must be sensitive to the effects that residuals from the system will have on health, welfare, and the ecological system. If this sensitivity is incorporated into the development and implementation process, these domestic resources can be broadly utilized in harmony with the environment. These effects act as a constraint

on the technical requirements for control, the siting of the system, and the value of the system as a producer of energy. Further, knowledge of the effects of the system before it is implemented will avoid the enormous costs associated with the need to retrofit controls on an operational system or to clean-up the wastes once they have been discarded. The environmental research program will provide the technical basis for understanding these environmental consequences and for balancing the environmental and energy system costs to the society in an equitable manner.

While in theory the environmental research program does not add 1 BTU to the energy balance, in practice achievement of the energy supply forecasts made by each technology panel are dependent on demonstrating to a concerned and increasingly sophisticated public that environment impacts are understood and controllable to an acceptable level. Recent history has demonstrated the delays that can occur owing to the lack of a sound understanding of energy-related environmental questions. Examples of these delays which have affected energy supplies have been the Alaska pipeline and delays in nuclear licensing. Delays also affected implementation of environment controls, as exemplified by litigations of utilities against installation and operation of SO_X flue-gas cleaning technology. The environmental research program would provide the basic understanding necessary to evaluate and measure environmental impacts, determine their effects, and develop and implement timely and minimum cost environmental controls.

Successful implementation of this environmental research program will affect all aspects of the energy program and could be the definitive determinant of optimal energy source use and of the feasibility of specific technology approaches. Disruption of the energy program can be prevented by anticipating potential problems related to each technology and by determining as rapidly as possible the effects on health, ecosystems, and society. Perhaps the largest barrier to be faced is the need to convince energy-related technologists and planners that this seemingly distractive commitment must be made at the outset to prevent very major disruptions in energy production.

Program Plan:

1. **Pollutant Characterization, Measurement and Monitoring**

The research programs in the FY 1975-1979 period will:

a. Develop and apply methods to determine the characteristics of pollutants associated with existing and future energy systems and technologies.
b. Improve precision and accuracy of ambient and source measurement methods and procedures for controlling radiological pollutants.

c. Develop continuous ambient and source measurement methods and procedures for pollutants for which no standard has been established (e.g., fine particulates, sulfate, nitrate).
d. Develop quality assurance procedures for environmental monitoring and measuring activities.
e. Develop and demonstrate advanced monitoring techniques, i.e., remote and in situ sensors.
f. Develop and implement data acquisition, retrieval, and assessment procedures permitting maximum Federal, regional, and local application of monitoring information.
g. Develop more precise performance specifications for calibration of instrumentation used to measure pollutant concentrations.

2. **Environmental Transport Processes**

Specific research activities in the FY 1975-1979 will determine:

a. Cooling-system plume behavior.
b. Atmospheric interactions in both dry and wet-scrubbed plumes from fossil energy systems (especially respirable sulfate-particle formation, SO_2 oxidation rate, interaction with urban pollutants, and NO_X behavior).
c. Dispersion of plumes in rough terrain.
d. Low-level dispersion pathways and ultimate fates of radionuclides from nuclear plant releases, especially at low wind speeds and including building wake effects.
e. Thermal and pollutant dispersion pathways and ultimate fates in streams, lakes, and groundwaters.
f. Physical and chemical transformation of pollutants in streams and lakes.
g. Thermal and pollutant diffusion in characteristic coastal water.
h. Physical and chemical transformation of pollution in coastal waters.
i. Transfer mechanisms of atmospheric sulfur and nitrogen oxides to soils and economic crops.
j. Impact of moisture and heat release on local climate.
k. Model for precipitation scavenging of sulfur.
l. Dry deposition of atmospheric pollutants.

3. **Effects: Health, Ecological, Welfare and Social**

Specific health-effect research activities in the FY 1975-1979 time period are:

a. Strengthening of scientific bases for existing primary ambient air quality standards. Although these standards were formulated upon the best available information at the time of their promulgation, there is a pressing need to place these standards on as firm a scientific basis as possible before they are implemented. Gaps in knowledge are particularly evident with respect to nitrogen oxides.
b. Evaluation of health effects associated with exposures to air

pollutants for which ambient air quality standards do not presently exist. These include effects of fine particulates and suspended sulfates, as well as known or suspected carcinogenic hydrocarbons.

c. Evaluation of health effects associated with exposures to trace metals and persistent chemicals. Although these are in reality multimedia problems, airborne exposures can be important. Current strategies for long-term control of lead mobile source emissions and for control of lead and cadmium stationary source emissions are dependent upon availability of additional health effects information.

d. Evaluation of health consequences resulting from the impact of fuels and fuel additives upon regulated as well as nonregulated pollutants. Work includes safety assessment of catalysts to be used in emission control systems for automobiles as well as protocol development for safety assurance testing.

e. Definition of effects of simultaneous exposure to a number of air pollutants. This includes assessment of nonpulmonary effects due to air pollution, such as decreased resistance to infection, and impact upon health of future generations via teratogenic or mutagenic effects.

f. Investigation of long-term low-level effects of fossil fuel and radioactive pollutants. This will include studies of genetic and late somatic effects and is of particular importance because such effects will ultimately aid in the determination of the safe levels for pollutants in the air, water, land, foods, etc.

g. Development of means of combating adverse effects of pollutants on exposed humans. Such efforts are needed to decrease harmful effects in cases of acute, intermittent, and long-term low-level exposures.

h. Provision of information on health effects essential to cost-benefit-risk decisions in the choice of energy systems when diverse, competing technologies exist.

Specific ecological effects research in the FY 1975-1979 time period will:

a. Assess the environmental effects and impacts of coal, oil, oil-shale, uranium, and geothermal extraction techniques and predict ecosystem effects, permitting enhancement of benefit-cost-risk ratios by suitable land management policy.

b. Determine the environmental effects of radionuclide, hydrocarbon, and other fuel transport, storage, or waste releases during energy conversion and waste disposal. This will include determining the accumulation ratios and transfer rates of secondary pollutant dispersal through the food chains and other pathways and determining strategies for concentration and/or decontamination in order to minimize residual long-term ecosystem effects, including those impinging on man.

c. Determine pollutant pathways and toxicities so as to guide routine

and nonroutine releases from energy conversion and reprocessing plants. Both geochemical and ecosystem studies will be conducted to provide guidelines and criteria for siting of process facilities and disposal areas for both liquid and solid wastes generated by both nuclear and nonnuclear plants.

d. Determine the ecosystem costs of thermal shocks from power plant waste-heat release, of entrainment and impingement in the cooling systems, and of cooling tower blow-down as well as the impact of anti-fouling additives. Additionally, the ecosystem impacts and synergistic effects of effluents, such as radioactive materials, trace metals, noxious gases, organic compounds and other substances produced during energy generation, will be evaluated, and management strategies will be instituted for minimizing these impacts.
e. Develop biological indices (species, diversity, fecundity, natality, mortality, etc.) for ecosystem impact evaluation. A systems approach encompassing laboratory, greenhouse, microcosm, and large-scale field experimentation will be used to address the problem. This systems approach requires a model that is structured in such a way that those subsystems most affected by pollution can be sensed. A more detailed analysis of these components will then be made with a view to assessing the site, time, and mechanism of potential pollution effects so as to guide siting to the least environmental damaging places.
f. Conduct large-scale ecosystem studies on dedicated, controlled-access parcels of land and water, such as environmental research parks, and through the biome studies developed under the International Biological Program.
g. Produce a number of relatively simple, reliable estimators of ecological impact and estimate the extent and duration of observed effects using the above capabilities and data base.

Social and welfare effects research in the FY 1975-1979 time period will address:

a. The assessment of material deterioration problems in the field at present.
b. The factors affecting erosion of stone—characterization and parametric evaluation.
c. The study of pigment degradation in artistic and other works.
d. The assessment of construction metals and their uses in construction, art, and transportation.
e. Development of a reasonable standard protocol for societal assessment techniques to be used by different energy research and development groups (opinion surveys, handbooks, etc.).
f. Development of and testing of models of value changes in impact assessments. Compare results of system analyses used by all groups.
g. Implementation and dissemination of results (in lay terms) to government policy-making bodies, etc.

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4. Environmental Assessment and Policy Formulation

Priority research in the FY 1975-1979 time period will:

a. Determine the ability of existing and proposed institutional structures for energy decision making to accurately represent the environmental concerns of all segments of the population.
b. Develop methodologies for intercomparing the environmental risks and benefits of highly disparate energy systems.
c. Lead to improved quantification of both environmental costs and benefits to society and development of techniques by which the cost of pollution control can be more effectively internalized.
d. Develop methodologies for synthesizing information produced by the environmental research programs.
e. Analyze alternative implementation techniques for reducing environmental impact (e.g., environmental impact statements, environmental standards, economic incentives).

Supporting Evidence:

It is clear that a sound base of scientific capability exists for this work. No major difficulties with scientific feasibility are foreseen in achieving the goals. Few engineering problems are anticipated, but close cooperation between biologists, environmental scientists, and technology development engineers will be required to minimize environmental impacts of present and new technologies. The major potential barriers are: (1) inadequate communication between the environmental scientists and the energy technology developers and (2) lack of established policy for the timely incorporation of environmental impact data into the development and implementation of energy systems and associated technology.

Budget:

	Dolls-s in Millions					
	1975	1976	1977	1978	1979	Total
Pollutant Characterization, Measurement and Monitoring ...	13.0	18.5	21.1	21.4	22.0	96.3
Transport of Pollutants	20.5	24.0	23.0	23.0	19.5	110.0
Effects Research	69.1	76.4	78.4	95.0	94.8	413.7
Environmental Assessment and Policy Formulation	3.0	3.0	6.0	8.0	10.0	30.0
TOTAL	105.9	121.9	128.5	147.4	146.3	650.0

B. BASIC RESEARCH $300M

Program Goals:

To explore basic phenomena, processes, and techniques in those physical, chemical, biological, environmental, and social sciences areas bearing on energy and to ensure the development of new basic knowledge in these areas.

Program Objectives:

1. **Materials**

   a. To understand the effects of high-temperature environments and thermal shock on material strength, microstructural changes of surface, and bulk properties. To provide the understanding needed to synthesize new materials suitable for energy applications under these environments.
   b. To understand radiation effects, void formation, sputtering, ion-penetration effects of individual ions from nuclear reactions, and embrittlement by hydrogen and radiation.
   c. To better understand superconductivity, electronic conduction at high temperatures, insulator breakdown, electrolyte behavior, and ion conductance phenomena relevant to energy production and utilization.
   d. To understand the corrosion processes related to energy systems, including stress and sulfur corrosion, grain boundary penetration, and liquid-metal compatibility.
   e. To understand photovoltaic properties, effects of impurities, and new semiconductors.
   f. To understand the properties of ceramic materials including strength and resilience.

2. **Chemical, Physical, Engineering Sciences**

   a. To enlarge our understanding of hydrogen production by thermochemical, photochemical, and biochemical processes from nonfossil sources including water. To expand our understanding of hydrogen storage systems, principally as hydrides.
   b. To understand catalysis and how surfaces catalytically alter reaction mechanisms sufficiently to be able to design and identify new catalysts and catalytic techniques, to identify and understand the role of reactive intermediates, to understand the structure of enzymes and how they effect catalytic alteration of reactions, including immobilization.
   c. To understand kinetic and heat-transfer processes which affect combustion efficiencies and other energy processes.
   d. To provide needed thermodynamic data on low-temperature liquids, high-temperature gases, liquid-metal alloys, hydrogen-

producing reactants, and intermediates, and to enlarge understanding of theory of solutions and complex reaction equilibrium.

e. To understand turbulent mixing in the atmosphere and ocean, in polymer solutions, and in two-and-three-phase flow. To be able to effect more efficient reactions by understanding and applying the principles of turbulent mixing fronts and flows in porous media.
f. To understand the chemical and physical interactions involved in separation processes. To understand laser stimulated interactions as applicable in isotope separation.
g. To provide needed nuclear properties for new fuels and other nuclear materials. To better understand interactions in molecular, atomic, and nuclear physics, including low- and high-energy interactions.
h. To improve understanding of electrochemical processes including oxygen reduction mechanisms in aqueous solutions, ion mobilities in solid electrolytes, electrode potentials, overpotential foaming, and current density limits.
i. To be able to measure pollutants and/or trace elements in the ppm and ppb ranges, measure transport and thermodynamic properties, and to measure particle-size distributions in submicron range.

3. **Biological**

a. To understand the bioconversion of animal and plant wastes to usable fuels including the photosynthetic process and the fixation of nitrogen.
b. To understand detoxification of energy-related wastes and the biological effects of toxic substances.
c. To understand the aspects of hydrology, oceanography, climatology, and meteorology which are most affected by energy systems, including dynamics affecting transport and disposal of thermal and material loads at local, regional, and global levels.
d. To understand the ecosystem, particularly the interactions resulting from energy production and utilization.
e. To enlarge understanding of geochemistry and environmental geology, including faulting, rupture, slope stability, seismology, and rock and soil mechanics.

4. **Plasmas**

a. To understand the behavior of plasmas, the factors that affect their interactions with electromagnetic fields and radiation, and direct energy conversion systems.
b. To encourage thinking about very large energy supplies such as orbital solar stations, colliding-beam fusion reactions, kinetic energy of ocean currents, rotational energy of spin and orbital motion of the earth, and nuclear energy storage concepts.

5. Mathematical and Social

a. To develop mathematical and computer techniques for handling large and complex technical and socioeconomic energy models. To further develop mathematical approaches to energy problems.
b. To understand social and psychological responses, including motivational studies and national attitude analyses, as related to changing energy situations. To better understand the energy needs for population support.
c. To develop techniques needed to understand the effects of national regulatory policy and international relations on the dynamics of energy research and development.

Contributions to the Energy System If Success Is Achieved:

The overall benefits of research are to ensure development of efficient energy concepts, including the identification of new means for meeting energy requirements, and to provide the base of knowledge that will facilitate solutions to currently unanticipated problems, thus reducing national costs of energy utilization. The recommended research is aimed mainly towards obtaining knowledge that will ultimately lead to greater social and economic benefits from energy utilization and that will lead to a lessened impact on our energy resource base and on our environmental and ecological systems.

Specifically, research on materials should narrow the gaps in the fundamental understanding needed to improve, control, and predict the properties of materials utilized in the exceptionally hostile environments of energy processes. Superconducting materials research is expected to make very long distance transmission of electricity possible, providing savings in transportation costs and flexibility in siting of power plants. Research in chemical, physical, and engineering science areas should lead to more efficient and environmentally acceptable utilization of our resources. Such research could lead, for example, to economical production of hydrogen from water or renewable nonfossil sources. Advances in catalysis, a field ripe for exploitation, could significantly affect the economics of such conversion processes as coal liquefaction and gasification. Basic biological research will increase our knowledge of biochemical generation of fuels from organic materials and the biological and environmental effects of toxic effluents. Plasma research supports conversion techniques, such as MHD, fusion, gas lasers and thermionic devices. Contributions from discoveries of entirely new concepts could be revolutionary in nature and could alter the entire approach to energy production and utilization. Basic work in the mathematical and social sciences leads to improvements in many fields, especially in the socioeconomic area where better understanding could result in a more stable and responsive technical, socioeconomic, and political system.

Program Plan:

Part of the multidirectional research program is designed to find answers to questions now visible. Another part is intended as insurance against unknown future barriers to development progress. A very small part of the multidirectional research effort is to encourage creativity and imagination along lines not yet chartable in the long-term concerns for renewable energy.

The greatest value is realized from research when fruition precedes the demand for implementation. For example, research on fusion reactor materials problems is not expected to impact in the same time frame as research on catalysis for coal conversion processes. However, because of the lead time required to provide the understanding to resolve the materials problems of the fusion reactor, it is imperative that materials and catalysis research be accelerated as soon as possible. Every effort is expected to plan the research so as to anticipate the needs of future energy developments while at the same time providing the fundamental support needed for currently developing programs. The most promising proposals for research that address the specific objectives cited above will be supported as necessary to expand basic understanding.

Since research frequently suggests quite new lines of development, not contemplated when the program was first defined, flexibility must be assured to most effectively capitalize on new advances.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	5 Yr. Total
Materials	8	11	12	12	12	55
Chemical, Physical, Engineering	16	22	24	24	24	110
Biological	12	15	17	18	18	80
Plasmas	3	4	5	4	4	20
Mathematical	4	6	8	9	8	35
TOTAL	43	58	66	67	66	300

C. MANPOWER DEVELOPMENT $50M

Program Goal:

To support the energy research and development program by ensuring that technical and managerial manpower skills are available in quantity and quality sufficient to meet the needs of the program.

FY 75-79 Program Objectives:

1. To enlarge educational faculty capabilities to educate and train technical manpower in the skills required to conduct energy research and development.
2. To enhance the effectiveness of managerial personnel in Government and industry in planning and executing programs in energy research and development.
3. To enlarge the base of manpower skilled in energy and energy-related research and development by supporting student participation in energy and energy-related studies and training activities.
4. To enlarge manpower training capabilities in energy research and development organizations to retrain and redirect technical manpower at all levels.

Contributions to the Energy System If Success Is Achieved:

A five-year \$10 billion Federal program in energy research and development represents at least 50% increase over previous projections. Manpower requirements will be increased similarly. At an average rate of \$2 billion per year and an average cost per technical man-year of \$50,000, the energy research and development program would employ 40,000 scientists, engineers, and technicians. Currently, only half that number are employed in federally supported energy research and development. While the potential for redistribution of technical manpower is high, reorientation or retraining is still necessary to a significant degree, and major growth in the longer term must come from the students now in universities.

The proposed funding level for manpower development would support a program that would reach over 2000 people annually, many of them faculty and managers responsible for education and training of the future manpower pool.

In recent years, government support for such a program has diminished; this is reflected in a lack of government direction in the development of manpower to meet National needs.

Program Plan:

To lay the proper foundation for a program of education and training directed to the development of a manpower base for energy research and development, initial emphasis must be on reorienting the faculty and managers responsible for such training. FY 75 funding would be used primarily for conducting or supporting institutes, special courses, workshops, conference, and off-campus appointments for university faculty currently teaching courses in science or technology or conducting research in science and engineering fields.

Program funding will support students or postgraduates who are pursuing studies in science and engineering. Traineeships, scholarships,

research stipends, and post-doctoral fellowships would be granted that would permit them to pursue studies and research in energy and energy-related subjects.

Finally, a moderate program of special courses, workshops, and conferences for managers would orient managers to the particular problems they will face in augmenting the technical manpower forces under their control.

Once a foundation has been laid by establishing a base of educators that would produce the needed manpower, emphasis can be shifted to the student or trainee, and more direct benefits should be forthcoming.

A cooperative program with national laboratories and contractors would lead to the retraining and reorientation of technical workers whose skills were inappropriate to specific needs. Government funding would support external educational assistance, manpower increases needed to conduct training programs, and stipends necessary to support trainees while undergoing training.

Supporting Evidence:

Research and student education conducted in U.S. universities is largely dependent on the source of support funds received and the stipulations attached to those funds. Programs offered and course structures are also dictated by the perceived need for graduates in particular disciplines. The need for a greatly enlarged effort in energy research and development has not been widely perceived, and Government funding for energy research and development has been somewhat stable. What is even more significant is the relatively new perception that coal would play a major role in energy supply for the remainder of this century.

It can be expected that this need for scientists and engineers capable of working on all aspects of the energy problem will be reflected in future support to U.S. universities, but a lead time is inherent to this shift in emphasis. Therefore, it is imperative that the Federal Government initiate such a program to reduce that lead time to the minimum practical.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	5 Yr. Total
Faculty Orientation	1.5	2.4	3.0	3.0	3.0	12.9
Managerial Training and Orientation	0.5	0.6	0.5	0.5	0.4	2.5
Student & Postgraduate Support	1.5	2.5	4.5	5.0	5.5	19.0
Industry/Laboratory Manpower Dev. Program	1.5	3.5	4.5	3.8	2.3	15.6
TOTAL	5.0	9.0	12.5	12.3	11.2	50.0

Appendix B

MAJOR RESEARCH AND DEVELOPMENT STRATEGY OPTIONS

Ten strategy options are available to policy makers whose goals are self-sufficiency, environmental improvement, and low energy cost. These are listed in Table B-1.

The first option (Class I) seeks balanced attainment of all three goals. Emphasis on the environmental goal (Class II) requires that the major effort go to obtaining and maintaining a clean environment. The options differ within that priority according to whether the secondary emphasis is placed on security, prosperity, or a balanced effort to achieve both. Classes III and IV place first priority on attaining security and prosperity, respectively, with

Table B-1.–POSSIBLE RESEARCH AND DEVELOPMENT STRATEGIES (RELATIVE PRIORITIES AMONG GOALS)

I.	Balanced Attainment of All Three Goals	
II.	A.	Environment–Security–Prosperity
	B.	Environment–Prosperity–Security
	C.	Environment–Balanced Security/Prosperity
III.	A.	Security–Prosperity–Environment
	B.	Security–Environment–Prosperity
	C.	Security–Balanced Environment/Prosperity
IV.	A.	Prosperity–Security–Environment
	B.	Prosperity–Environment–Security
	C.	Prosperity–Balanced Environment/Security

corresponding follow-up choices among the remaining goals. Implications of the four major strategies are discussed in the following sections.

Analysis of Research and Development Strategy Options

Class I. Balanced Attainment of Environment/Security/Prosperity. This approach holds that the Nation is in reasonably good shape as regards each goal and that there are no clear preferences for priorities among the three. A research and development program would be structured to make gradual progress toward each goal. This progress would be uneven, to be sure, as different technologies became economically viable at different rates, but the overall trend would be one of steady improvement in all three areas. If a big breakthrough occurred in one area, research and development funds would be shifted out of that area into the other two. If one area failed to show reasonable progress, it would draw research and development money from the other two until it began to show more movement. The "something-for everybody" character of this option makes it attractive. The difficulty is that it postpones attainment of any one goal until all of them can be attained.

Class II. Environment First. The Class II options proceed from a judgment that economic prosperity and security are adequate for the moment and that a clean environment should be the first priority. Research and development would focus on identifying and removing undesired environmental effects of energy technologies. Ways to use resources cleanly even at higher prices for energy would be a major research and development effort. Environmental quality would be the determining factor when considering the introduction of new processes or the advisability of increasing imports.

Among options IIA, IIB, and IIC, proponents would differ with respect to what should be done once satisfactory progress had been made toward a clean environment. Some would seek security or self-sufficiency next; others would concentrate on lowering costs; and still others would pursue both on a balanced basis, thereby postponing the time of attainment of both.

Class III. Security First. This approach holds that the Nation is too vulnerable to the interruption of crucial energy supplies and that its first task is to regain energy self-sufficiency. The energy research and development program would focus on finding domestic substitutes for imports. As set out in Chapter 5, option IIB is the recommended strategy.

The options within this class differ with respect to the priority between the follow-on objectives, with corresponding implications for the establishment of a specific research and development program.

Class IV. Prosperity First. This set of options completes the list of choices. It would place the major research and development emphasis on achieving low energy costs. Individual options in the class again differ with respect to the priority assigned the two follow-on objectives, clean environment and security.

CRITERIA FOR FUNDING FEDERAL PROGRAMS

The criteria discussed below are listed and rated in Table B-2. In every case, an individual subprogram can be rated "high," "medium," or "low" for each criterion. The differences among these ratings provide guidance for relative funding priorities.

Research and Development Phase

Adequacy of Scientific Base. This is the state of chemical, physical, geologic, and other knowledge about the physical properties and location of various fuel sources. Identification of areas of limited knowledge may suggest important possibilities for developing from basic research the means to increase supply or enhance the efficiency of energy production and use. Prospects for advances depend upon the availability of researchers and the active interest of university centers and industry.

Probability of Future Technological Success. Basic research must be translated into proof-of-concept experiments and pilot and demonstration plants, or their equivalent in other programs. This process sometimes exposes gaps in basic knowledge; lack of component hardware may cause substantial delays. Reasonable assessment of technological feasibility must examine such potential difficulties in an attempt to estimate the "elasticity" of the research and development results to investment—how much positive effect greater funding would have in terms of earlier success or higher probability of success.

Feasible Absorbable Investment. This means the amount of money that can be profitably expended on the project's prospective rate of return. While it is always possible to spend more money, the law of diminishing returns inevitably applies.

Public and Government Consensus That Project Is Acceptable. Primarily from the point of view of environmental integrity, but also from the points of view of health, safety, and security, any new program or increased funding for a program must be measured against public acceptability in the research and development phase and in later stages of production. Although these considerations may be important only in later phases, they should be recognized early in the planning and research and development stage.

Implementation and Production Phase

Production Capability. Can the technology be implemented by the private sector at a profit? This depends on the price of the product relative to its cost. Significant new programs may require massive capital investment by industry and/or Government. Numerous supporting industries will be required for construction, operation, and maintenance of such plants. Availability of capital and of labor must be evaluated on a regional basis with efforts made to minimize possible labor shortages and other dislocations. The ongoing production costs as well as the research and development

investment must be estimated to establish the economically viable sale price of the product. To the extent that particular fuels can substitute for each other, their relative costs will influence project viability. The specific constraints are listed individually in Table B-2.

Environmental. Emission-control standards have greatly influenced the choice of fuels for power plants and vehicles. Such standards result from policy decisions based on data regarding hazards. Assessment of hazards should be included in program proposals to ensure balanced decisions. Environmental ill effects must be attributed a meaningful and substantial "cost" in that assessment. Clearly, fuel sources that disrupt the environment relatively less in the stages from mining to burning or disposal, or whose health hazards are relatively less, should be favored. Secondary and higher order undersirable effects, such as the problem of the water supplies required for coal and shale conversion plants, must be anticipated and cost-accounted as well.

Payoff Phase

Timing of Payoff. One of the goals of the energy program is to increase supplies as soon as possible. Accordingly, an assessment of the ability of the research and development program to achieve economic production capability earlier as a result of greater funding is important in determining the level and timing of funding. Estimates of the period of economic use of exhaustible fuel sources should include not only the estimated beginning of useful production but also forecasts of their lifetimes.

Economics of Payoff. If the probability of a program's success, the expected time of payoff, and the costs of creating the product are known, estimates can be made of the product's price and of the demand for it at varied prices. If the price of a new energy-generating system will be higher than the anticipated market price for substitutable products, it will not be economically viable.

Other Considerations

Security. It may be necessary to subsidize production from otherwise uneconomic sources to minimize dependence on foreign oil sources. For example, coal liquefaction and shale retorting may require special support in the form of subsidies or price guarantees to ensure their contribution to total supply as replacements for imported oil.

Political. Deviations from decisions based solely on economic considerations may be required. Decision makers may wish to maintain employment in various parts of the country so that capital investment is distributed throughout the country and among industries or to protect population centers and wilderness areas from unseemly exploration and mining.

Regional Aspects. Certain energy research and development programs may have limited payoff on a national basis, but sufficient local or regional

payoff to be justified. Solar energy for space heating in the South and Southwest and geothermal sources in the West appear promising even though total energy production in BTU's is relatively small compared to national needs.

Environmental. Many environmental constraints can be included in the costs of energy production. Some environmental effects, however, are not readily corrected by investments of dollars and effort. These are considered under this category.

Determination of Relative Priorities—An Illustration

The considerations used to set priorities among candidate energy research and development programs are displayed in Table B-2. Ratings based on evaluations contained in the subpanel report in this area compared to subpanel reports regarding other programs have been assigned. The matrix shown is a systematic way to record estimates and arrange them in a manner that facilitates comparisons. The comparisons are the basis for ranking the programs. The energy research and development programs are ranked illustratively on the basis of the criteria indicated. Each program has been assigned a numerical value for each criterion: 3, 2, or 1, on the basis of high, medium, or low desirability, respectively. The reader may choose to substitute other criteria and weights. For example, projects judged to have the highest potential for Savings or Enhancement in Petroleum have been given a 3. Projects offering lower but still substantial potential savings have been given a 2, and those with the lowest potential are assigned a 1 in that column. Those with near-term timing receive a 3, mid-term a 2, and long-term a 1. Illustrative program rankings (totals) are given at the right.

The unweighted total score gives equal importance to each of the criteria. Since certain criteria are more important than others, another criteria weighting scheme was devised. The single criterion deemed most important in each of the three phases (I. Research and Development, II. Implementation and Production, and III. Payoff) was given a weight of 3, the criterion deemed second most important was given a weight of 2, and all other criteria were weighted 1. Other weights could be substituted. In this case, a value of 3 in a criterion weighted 3 generates a contribution of 9 to the total score, a value of 2 in a criterion weighted 1 generates a total score contribution of 2, etc. The total weighted rating for each program summed over all criteria is also shown in Table B-2.

Other schemes could be applied in a similar manner. For example, another approach would be based on multiplicative rather than additive weights, totaling the indicators in each of the three successive phases. This method would tend to favor more strongly those programs having good prospects in each phase, at the expense of those having the same additive but less even prospects. The particular scheme used does not seem to make too much difference. Projects having more-immediate payoffs are generally ranked higher than longer term payoff projects, no matter what scheme is used.

Table B-2.—CRITERIA FOR SPENDING R&D MONEY WISELY

(Weights: 3 High, 2 Medium, 1 Low Spending Priority)

CRITERIA / PROGRAM AREA	I. R&D Phase					II. Implementation and Production Phase					
	Adequacy of Scientific Base	Probability of Future Technological Success	Feasible Absorbable Investment	Project is Acceptable	Public and Govt. Consensus That Project is Acceptable	Expected Price/Cost of Production	Cost of Substitutes	Environmental Acceptability	Need for Government Role	Adequacy of Resource Reserves	Labor Available
Weighting		3x			2x	3x	2x				
Resource Assessment	3	3	1		3	3	3	3	2	3	3
Mining Coal and Shale	3	3	2		2	3	3	1	2	3	2
Surface Mining	3	3	2		2	3	3	1	3	3	2
Underground Mining	3	3	2		2	3	3	2	2	3	2
Oil Shale Mining and Reclamation	2	3	2		2	2	3	1	2	3	2
Energy and Fuel Transportation, Distribution, and Storage	1	3	1		3	2	2	2	1	3	3
Coal and Shale Processing and Combustion	3	3	3		3	2	3	3	3	3	3
Clean Combustion of Coal	3	3	3		3	3	3	3	3	3	3
Coal to Pipeline Gas	3	3	3		3	2	2	3	2	3	3
Coal Liquefaction	2	3	3		2	2	3	2	3	3	3
Support R&D for Coal	3	2	2		3	2	2	3	3	3	2
Pollution Control Technology Coal	3	2	3		3	3	3	3	2	3	2
Conversion Techniques	2	3	3		3	2	2	3	2	3	3
Low BTU Gas	3	3	3		3	2	2	3	2	3	3
High Temp Gas Turbines	2	3	3		3	3	2	3	2	3	3
Magnetohydrodynamics	1	2	2		3	2	2	3	3	3	3
Other (Fuel Cells, Use of Waste Heat)	2	2	1		3	2	3	3	2	2	3
Oil and Gas	3	3	2		3	3	3	2	1	2	3
Geothermal	1	2	2		3	2	1	2	2	2	3
Solar	1	2	1		3	1	1	3	3	3	3
Building Heating and Cooling	3	3	1		3	2	2	3	3	3	3
Other (Centralized)	1	2	2		3	1	1	3	3	3	3
Fusion	1	1	2		3	2	1	3	3	3	2
Confinement	1	1	2		3	2	1	3	3	3	2
Laser	1	2	2		3	2	1	3	3	3	2
Fission	3	3	3		3	3	3	2	2	3	2
LMFBR	3	3	3		3	3	3	2	2	3	2
Other	3	3	3		2	3	2	2	2	3	2
Advanced Transportation Systems	2	1	2		3	2	3	3	2	3	3
Automobile and Truck	1	1	2		3	2	3	3	2	3	3
Air	3	1	1		3	1	3	3	2	3	3
Rail and Bus	2	2	2		3	2	3	3	2	3	3
Ship (Nuclear)	3	2	2		3	3	3	2	1	3	2
Conservation (End-Use Sector)	3	3	2		3	3	3	3	3	3	3
Environment											
Multidirectional Res											

II. Implementation and Production Phase					III. Payoff Phase		IV. Noneconomic Consideration					
Hardware Development	Private Capital Available	BTU's Supplied or Conserved	Saving or Enhancement in Petroleum	Timing (Near, Mid, Long)	Project Score (Unweighted)	Project Score (Weighted)	Federal Regulatory	Environmental	Security	Political	Regional Distribution	PROGRAM AREA
			2x	3x								Weighting
3	2	3	3	3	41	68	1					Resource Assessment
2	3	3	3	3	39	65	3					Mining Coal and Shale
1	3	3	3	3								Surface Mining
2	3	3	3	3								Underground Mining
2	3	3	3	3								Oil Shale Mining and Reclamation
2	3	3	2	2	32	53	2					Energy and Fuel Transportation, Distribution, and Storage
2	2	3	3	3	42	67	3					Coal and Shale Processing and Combustion
2	2	3	3	3								Clean Combustion of Coal
2	3	3	3	3								Coal to Pipeline Gas
2	1	3	3	2								Coal Liquefaction
2	1	3	3	3								Support R&D for Coal
1	1	3	3	3								Pollution Control Technology Coal
1	2	3	2	2	.36	55	1					Conversion Techniques
2	2	3	2	2								Low BTU Gas
1	2	3	2	2								High Temp Gas Turbines
1	2	3	2	2								Magnetohydrodynamics
2	2	2	2	1								Other (Fuel Cells, Use of Waste Heat)
3	3	3	3	3	40	67	3					Oil and Gas
2	2	1	1	2	28	45	1					Geothermal
1	1	2	1	1	27	40	1					Solar
1	1	2	2	1								Building Heating and Cooling
1	1	2	1	1								Other (Centralized)
1	1	3	2	1	29	43	2					Fusion
1	1	3	2	1								Confinement
1	1	3	2	1								Laser
2	3	3	2	2	39	63	3					Fission
2	2	3	2	2								LMFBR
2	3	3	2	1								Other
1	2	3	3	2	35	54	2					Advanced Transportation Systems
2	3	3	3	2								Automobile and Truck
2	2	3	3	2								Air
1	1	3	3	2								Rail and Bus
1	1	3	3	2								Ship (Nuclear)
3	2	3	3	3	43	70	3					Conservation (End Use Sector)
												Environment
												Multidirectional Res

Given the array of potential research and development programs, the mix of programs that can be recommended does not vary too much even when strikingly different strategies are adopted. The criteria can be given extremely high or low weights for environmental acceptability, for example, or for price without drastically altering the ranking of programs. On the other hand, the approach of seeking information to quantify these parameters may become more useful as progress is made on several major programs. Then the projections of costs and technological capacity to overcome environmental constraints can be better evaluated and compared among subprograms.

Illustrative Use of the Criteria Matrix

Rating a Single Program. The basis for rating one program area, Energy and Fuel Transportation, Distribution, and Storage, is described below to illustrate the potential use of the criteria matrix. Subprograms in transmission include demonstration high-voltage a-c and d-c electricity transmission projects, both above ground and below ground, and the use of superconducting underground cables. Storage subprograms include development of sodium-lithium batteries, superconducting magnets, and a flywheel facility. Transportation subprograms include work on surface and underwater arctic ships.

Research and Development Phase. Because much proof-of-concept laboratory work will be required in these programs, Adequacy of the Scientific Base was given a rating of 1. Probability of Future Technological Success received a 3, a high rating. Feasible Absorbable Investment, given the laboratory stage of many subprograms, was considered relatively low and assigned a 1. The projects would improve efficiency and might improve the environment (through underground transmission and submarine tankers having lower spill potential), resulting in a high Acceptability rating of 3.

Implementation and Production Phase. The projects in this area fall in the middle range of the Price/Cost of Production rankings, resulting in a rating of 2. These projects received a Cost of Substitutes ranking of 2 because most of the prospective benefits could be achieved by burning more coal. The necessary Government Role received a 1 rating owing to the short-term payoff of the subject projects and the existence of many industry programs in these areas. Resource Reserves to meet the need to transmit electricity continuously are excellent and are rated 3. Adequate Labor and Capital are available for a rating of 3, but some associated Hardware Development is a challenge, resulting in a rating of 2.

Payoff Phase. If the projects are successful they offer the prospect of conserving substantial BTU's of energy (rating of 3). This would be coal conservation rather than a saving in Petroleum, so the latter is rated 2 as is the Timing criterion.

On the basis of the program rankings, the energy research and development programs have been ordered in priority in Table B-3. The ordering does differ, but not substantially so, between the weighted and

unweighted methods. In general, those programs which emerge with highest priorities are those with nearest term potential payoffs.

Table B-3.–ILLUSTRATIVE PROGRAM PRIORITIES BASED ON CRITERIA

Weight Criteria	Total Rank	Unweighted Criteria	Total Rank
Conservation	(70)	Conservation	(43)
Resource Assessment	(68)	Coal and Shale Processing	(42)
Oil and Gas	(67)	Resource Assessment	(41)
Coal and Shale Processing	(67)	Oil and Gas	(40)
Mining Coal and Shale	(65)	Fission	(39)
Fission	(63)	Mining Coal and Shale	(39)
Conversion Techniques	(55)	Conversion Techniques	(36)
Advanced Transportation Systems	(54)	Advanced Transportation Systems	(35)
Energy and Fuel Transportation Distribution and Storage	(53)	Energy and Fuel Transportation Distribution and Storage	(32)
Geothermal	(45)	Fusion	(29)
Fusion	(43)	Geothermal	(28)
Solar	(40)	Solar	(27)

Rating Two Competing Programs. The basis for assigning weights to two closely related programs is described below to illustrate the rationale by which different weights were given to competing programs. Both programs, enhanced oil and gas production and coal liquefaction, have the same goal–production of refinery feed stock.

Research and Development Phase. Adequacy of the Scientific Base is considered excellent in oil recovery, but poor for the development of economically viable coal liquefaction. Both programs are considered to offer high probabilities of Future Technological Success. More work must be done in coal prior to demonstrating economic feasibility, and a larger list of priority projects exists, implying greater Feasible Absorbable Investment here than in oil and gas. Consensus of Acceptability is good for both projects, but coal liquefaction is less acceptable both on the basis of requiring extensive mining and the use of valuable water resources.

Implementation and Production Phase. Coal liquefaction is expected to have worse Price/Cost prospects than enhanced oil and gas recovery. Both proposals augment the supplies of high Cost Substitutes, namely, oil. Environmental Acceptability of both is less than optimal, with debits in both mining and in the risk of oil spills. Need for a Government Role is far greater in coal liquefaction than in oil, where the time of payoff is much shorter and better technology already exists. Abundant Resource Reserves of coal are

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known to exist, but the extent of exploitable oil reserves is less certain. Labor is Available in both areas, but Hardware Development is less advanced in coal liquefaction. Private Capital is judged to be readily available to implement enhanced recovery of oil but is much less so for coal liquefaction due to the latter's longer term payoff and less certain economics; also the more fragmented coal industry lacks the financial resources of the oil industry.

Payoff Phase. Both coal liquefaction and enhanced oil recovery offer the prospect of enhancing both the BTU's and Petroleum Savings. Timing is more favorable for oil recovery than coal liquefaction.

Project Priority and Project Funding

Programs given the highest priorities–conservation, oil and gas production, and utilization of coal–have been budgeted more liberally than those programs of lesser priority in terms of size and term of payoff. The dollar amounts proposed for individual programs cannot be ranked in the same fashion as the priority, since the overriding criterion is how much funding can be prudently spent. A relatively massive infusion of Federal funding is proposed in the area of conservation. A very helpful increment of Federal assistance to the huge expenditures of the oil and gas industry is included, anticipating that the bulk of investment in these areas will be derived from private sources.

In the case of coal conversion, a variety of ambitious programs has been proposed for substantial funding in conjunction with a substantial contribution from industry consistent with the anticipated capacity to generate the people, hardware, and initial methodologies to push ahead with major pilot and development stage projects. For programs of long-term and mid-term payoff that lack significant private interest at present, such as the breeder and fusion programs, continued support has been proposed to ensure the energy future without interfering with the concentration of the accelerated spending program on shorter term prospects. In the cases of direct and indirect solar and geothermal applications, very large increases in spending have been recommended; however, the dollar amounts are much smaller than those for programs already involving massive construction costs for demonstration plants.

ALLOCATION OF FEDERAL FUNDS AMONG TIME PERIODS

The allocation of Federal funds among time periods by program elements, shown in Table B-4, provides a breakdown of the program elements given in Table 2-1. The key emphasis used in making these time-period determinations is the earliest projected commercial introduction of a technology derived from the combined Federal–industry development rather than the date of successful completion of the research and development program. There are obvious difficulties in assessing whether certain programs will be introduced in the short-term or mid-term, but the allocation is made through the best estimate available at this time.

Table B-4.—ALLOCATION OF FEDERAL FUNDS AMONG TIME PERIODS BY PROGRAM ELEMENTS

Self-Sufficiency Task	Short-Term Objectives ($ Millions)	Mid-Term Objectives ($ Millions)	Long-Term Objectives ($ Millions)
1. Conserve Energy and Energy Resources			
End-Use Conservation	135	15	
Improved Management	60		
High-Temperature Gas Turbine	210	105	
Advanced Cycles, Fuel Cells, and Other	110	100	
Advanced Auto Propulsion	260	40	
Rail, Bus, Ship, and Air Systems	205		
Energy and Fuel Transportation Distribution, and Storage	180	20	
Subtotal	1,160	280	
2. Increase Domestic Production of Oil and Gas			
Oil and Gas	310		
Resource Assessment	120	30	
Subtotal	430	30	
3. Substitute Coal for Oil and Gas on a Massive Scale			
Mining	285	40	
Direct Combustion	200		
Synthetic Fuels	855	415	
Common Technology	350	30	
Subtotal	1,690	485	
4. Validate the Nuclear Option			
Safety, Enrichment, HTGR, and Other	1,100	145	
Breeder Reactors		2,845	
Subtotal	1,100	2,990	
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible			
Fusion			1,450
Solar	50	50	100
Geothermal	85	100	
Subtotal	135	150	1,550
TOTAL	4,515	3,935	1,550

For each major program element, the subprograms and projects were individually analyzed. Examination of the program objectives, program plan, and contribution to the energy economy following successful research and development leads to the determination of those items which are definitely oriented towards early application or those items which are specifically geared for later introduction. Occasionally, estimated divisions of funding amounts were made when the desired information was not sufficient to make a clear determination.

ESTIMATING INCREMENTAL ENERGY VALUES RESULTING FROM RESEARCH AND DEVELOPMENT

The increments in energy savings and energy production that can be expected in 1980 and 1985 as a result of the research and development program are derived by analysis of the expected degree of implementation provided in the technical panel reports. The analysis was performed utilizing the Reference Energy System developed by Brookhaven National Laboratory. The reason for this type of analysis is that many of the proposed technologies will compete with each other for the same market application. This means that only the most efficient and economical technology will contribute to self-sufficiency. Also, when the combined potential of all technologies exceeds the annual requirements, the excess in one sector (e.g., electricity production) cannot be transferred to another sector (e.g., automobile transportation).

The Reference Energy System depicts a total network flow from supply sources through refining, conversion, and distribution to the final utilizing devices. Economic costs and technical efficiencies are included for each element of the energy system. The systems analysis can show the relative magnitude of impacts based on the assumption of successful research and development and timely implementation of the technology. By utilizing the technical panels' input data, the Reference Energy System provides a consistent framework for evaluating energy resource allocation and consumption patterns.

The energy-supply constraints, technical efficiencies of energy processes, and cost information permit one to examine the interactions within the entire energy system and develop the most likely energy future. By restricting the level of imported fuels and analyzing the types of energy sources which can satisfy a particular end use, the model will permit new, higher cost technologies to compete for the unsatisfied demands until the most-efficient resource allocation is found.

COMPARISON OF AGENCY PROJECTIONS AND RECOMMENDED PROGRAMS

It is impossible to provide any firm estimate of what the FY 1975-1979 level of funding would have been for Federal energy research and development in the absence of the President's June 29, 1973, initiative. No official figures exist. The closest approximation to the programs that might

have been conducted are agency five-year planning projections submitted during the FY 1975 budget cycle. An early draft of this report stated these amounts as $6622 million. More-precise definition of energy research and development programs and elimination of duplication resulted in the more-accurate estimate of $5931 million shown in Table B-5.

Table B-5.—FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY INDIVIDUAL PROGRAM ELEMENT, FY 1973-1975

	($ Millions)				
	Annual Budgets			FY 75-79 Programs	
Self-Sufficiency Task	Actual FY 73	Planned FY 74	Recommended FY 75	Recommended	Agency Projections
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	1,440	95
Reduced Consumption	12.1	22.3	29.9	210	15
Increased Efficiency	40.7	40	136.3	1,230	80
2. Increase Domestic Production of Oil and Gas	20	19.5	51.7	460	90
Production	12.8	11.2	31.7	310	50
Resource Assessment	7.2	8.3	20.0	150	40
3. Substitute Coal for Oil and Gas on a Massive Scale	88.8	167.2	405	2,175	845
Mining			45	325	
Direct Combustion			30	200	
Synthetic Fuels			240	1,270	
Common Technology			90	380	
4. Validate the Nuclear Option	395.8	517.3	731.7	4,090	3,672.3
Safety, Enrichment, HTGR, and Other	129.7	151.7	216.2	1,245.7	1,091.5
Breeders	266.1	365.6	515.5	2,844.3	2,580.8
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123	217.5	1,835	1,232
Fusion	74.8	98.7	145.0	1,450	1,132
Solar	4.2	13.2	32.5	200	80
Geothermal	3.8	11.1	40.0	185	20
TOTAL	640.2	889.3	1,572.1	10,000	5,931.3
Supporting Programs (incremental Federal funding to present programs)					
Environmental Effects				105.9	650
Basic Research				43	300
Manpower Development				5	50
				153.9	1,000

These projections assume substantial increases over the funding and pacing levels of current programs and include the initiation of large (and as yet unapproved) new construction projects for test and demonstration purposes in later program stages. Futhermore, the $5931 million is the sum of all agency requests rather than an independent overall coordinated program review. Thus, the total $5931 million almost certainly contains duplicate programs. It does not reflect the relative pacing and funding-level priorities that would only have led to a more-constrained estimate in the context of a balanced overall program review.

Clearly, the recommended program represents more than a doubling of the level of Federal effort devoted to energy research and development. Because of the uncertainty of the agencies' planning projections, Table B-5 also displays the data of Table 2-3 on recent budget levels. These permit a more meaningful comparison that shows the trend of actual spending experience in recent years compared to the current plan for the next five years.

Appendix C

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STATISTICAL SUPPLEMENT TO...

THE NATION'S ENERGY FUTURE

A REPORT TO RICHARD M. NIXON
PRESIDENT OF THE UNITED STATES

1 DECEMBER 1973

Submitted by Dr. Dixy Lee Ray
Chairman, United States Atomic Energy Commission

UNCLASSIFIED

RECOMMENDED FY 1975-1979 ENERGY R&D PROGRAMS AND SUPPORTING PROGRAMS

UNCLASSIFIED

December 1. 1973

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
(In millions $)

	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
I. Conservation									
Reduced Consumption	$ 12.1	$ 22.3	$ 29.9	$ 43.7	$ 51.5	$ 44.4	$ 40.5	$ 210.0	$ 15.0
Increased Efficiency	40.7	40.0	136.3	223.4	267.0	287.8	315.5	1230.0	80.0
Total Conservation	52.8	62.3	166.2	267.1	318.5	332.2	356.0	1440.0	95.0
II. Increase Production of Oil & Gas									
Production	12.8	11.2	31.7	89.1	79.5	59.5	50.2	310.0	50.0
Resource Assessment	7.2	8.3	20.0	23.0	29.5	37.5	40.0	150.0	40.0
Total Increase Production of Oil & Gas	20.0	19.5	51.7	112.1	109.0	97.0	90.2	460.0	90.0
III. Substitute Coal for Oil & Gas									
Mining			45.0	57.0	64.0	77.0	82.0	325.0	
Direct Combustion			30.0	35.0	40.0	44.0	51.0	200.0	
High BTU Gasification			35.0	75.0	92.0	81.0	57.0	340.0	
Coal Liquefaction			75.0	75.0	75.0	75.0	75.0	375.0	
Low BTU Gasification			30.0	37.0	42.0	48.0	43.0	200.0	
Synthetic Fuels - Industry Pioneering			100.0	100.0	55.0	50.0	50.0	355.0	
Environmental Control Technology			70.0	50.0	42.0	45.0	53.0	260.0	
Supporting R&D			20.0	22.0	24.0	27.0	27.0	120.0	
Total Substitute Coal for Oil & Gas	88.8	167.2	405.0	451.0	434.0	447.0	438.0	2175.0	842.0
IV. Validate The Nuclear Option									
Safety and Other	42.7	51.7	90.6	125.6	143.0	170.5	189.5	719.2	609.9
Uranium Enrichment	50.3	56.8	64.2	54.8	57.4	58.4	59.4	294.2	284.5
High Temperature Gas Reactor	7.2	14.2	40.0	44.7	24.2	26.9	28.0	163.8	128.6
Light Water Self-Sustaining Reactor	29.5	29.0	21.4	17.7	9.8	9.8	9.8	68.5	68.5
Liquid Metal Fast Breeder Reactor	253.8	356.8	477.0	538.6	510.8	524.2	506.0	2556.6	2470.6
Gas Cooled Fast Breeder	1.0	1.0	17.0	23.0	29.0	33.0	38.0	140.0	27.0
Advanced Technology	11.3	7.8	21.5	24.5	30.5	34.0	37.2	147.7	83.2
Total Validate The Nuclear Option	395.8	517.3	731.7	828.9	804.7	856.8	867.9	4090.0	3672.3
V. Exploit Renewable Energy Resources									
Fusion - Confinement	39.7	55.8	135.0	230.0	261.0	338.0	376.0	1340.0	1132.0
Fusion - Laser	35.1	42.9	10.0	20.0	25.0	25.0	30.0	110.0	--
Solar	4.2	13.2	32.5	39.9	41.4	42.2	44.0	200.0	80.0
Geothermal	3.8	11.1	40.0	41.0	40.8	35.7	27.5	185.0	20.0
Total Exploit Renewable Energy Resources	82.8	123.0	217.5	330.9	368.2	440.9	477.5	1835.0	1232.0
TOTAL ENERGY R&D PROGRAM	$ 640.2	$ 889.3	$1572.1	$1990.0	$2034.4	$2173.9	$2229.6	$10000.0	$5931.3

Summary Schedule
FY 1975-1979 Recommended Supporting Programs
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency
	1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
VI. Supporting Programs									
Environmental Research	$	$	$ 105.9	$ 121.9	$ 128.5	$ 147.4	$ 146.3	$ 650.0	$
Basic Research			43.0	58.0	66.0	67.0	66.0	300.0	
Manpower Development			5.0	9.0	12.5	12.3	11.2	50.0	
TOTAL SUPPORTING PROGRAMS	$	$	$ 153.9	$ 188.9	$ 207.0	$ 226.7	$ 223.5	$ 1000.0	$

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
Conservation
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency
	1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Reduced Consumption									
End-use Consumption	$ 6.8	$ 15.5	$ 19.9	$ 31.7	$ 37.5	$ 31.4	$ 29.5	$ 150.0	$ 5.0
Improved Management	5.3	6.8	10.0	12.0	14.0	13.0	11.0	60.0	10.0
	12.1	22.3	29.9	43.7	51.5	44.4	40.5	210.0	15.0
Improved Efficiency									
High Temp. Gas Turbine	--	--	18.3	66.8	79.3	76.8	73.8	315.0	
Adv. Cycle, Fuel Cells & Other	15.1	10.8	18.0	31.6	52.3	50.4	57.7	210.0	
Adv. Auto Propulsion	19.8	22.7	53.0	59.0	59.0	71.0	58.0	300.0	
Rail, Bus, Ship and Air	--	--	20.0	32.5	36.5	44.8	71.2	205.0	
Energy & Fuel, Trans. & Storage	5.8	6.5	27.0	33.5	39.9	44.8	54.8	200.0	
	40.7	40.0	136.3	223.4	267.0	287.8	315.5	1230.0	80.0
TOTAL CONSERVATION	$ 52.8	$ 62.3	$166.2	$ 267.1	$ 318.5	$ 332.2	$ 356.0	$ 1440.0	$ 95.0

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses..............................	$	$	$1,062.1	$1,311.0	$1,451.4	$1,519.3	$1,618.8	$ 6,962.6	$
Equipment.......................................			160.7	233.4	211.3	242.4	250.3	1,098.1	
Construction....................................			349.3	445.6	371.7	412.2	360.5	1,939.3	
TOTAL.......................................	$	$	$1,572.1	$1,990.0	$2,034.4	$2,173.9	$2,229.6	$10,000.0	$

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
(In millions $)

Operating Expenses	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
I. Conservation									
Reduced Consumption	$	$	$ 26.6	$ 34.5	$ 38.2	$ 36.6	$ 35.2	$ 170.9	$
Increased Efficiency			112.2	155.5	178.8	190.2	216.0	852.7	
Total Conservation			138.8	189.8	217.0	226.8	251.2	1,023.6	
II. Increase Production of Oil & Gas									
Production			26.0	70.2	67.6	51.6	45.9	261.3	
Resource Assessment			14.8	19.8	24.7	31.5	33.7	124.5	
Total Increase Production of Oil & Gas			40.8	90.0	92.3	83.1	79.6	385.8	
III. Substitute Coal for Oil & Gas									
Mining			28.5	34.5	36.0	41.5	45.5	186.0	
Direct Combustion			12.8	18.4	10.9	12.4	13.3	67.8	
High BTU Gasification			12.5	24.0	47.0	49.0	53.0	185.5	
Coal Liquefaction			52.0	38.0	38.0	40.0	45.0	213.0	
Low BTU Gasification			3.8	5.0	7.0	10.0	14.0	39.8	
Synthetic Fuels - Industry Pioneering			46.0	45.5	50.0	44.5	44.0	230.0	
Environmental Control Technology			42.0	25.0	22.0	30.0	47.0	166.0	
Supporting R&D			18.0	20.0	21.5	24.0	24.0	107.5	
Total Substitute Coal for Oil & Gas			215.6	210.4	232.4	251.4	285.8	1,195.6	
IV. Validate The Nuclear Option									
Safety and Other	37.7	45.1	74.8	88.5	104.6	117.6	130.6	516.1	440.1
Uranium Enrichment	25.2	31.1	44.1	47.0	48.0	49.0	50.0	238.1	165.2
High Temperature Gas Reactor	7.1	13.8	20.8	21.3	22.8	25.3	26.3	116.5	87.0
Light Water Self-Sustaining Reactor	28.8	23.7	21.1	17.4	9.3	9.3	9.3	66.4	66.4
Liquid Metal Fast Breeder Reactor	205.4	240.5	303.6	361.3	380.4	390.6	382.3	1,818.2	1,913.9
Gas Cooled Fast Breeder	1.0	1.0	13.0	21.4	26.8	30.2	34.6	126.0	24.0
Advanced Technology	11.3	7.8	21.1	23.8	29.2	32.4	35.6	142.1	83.2
Total Validate The Nuclear Option	316.5	363.0	498.5	580.7	621.1	654.4	668.7	3,023.4	2,779.8
V. Exploit Renewable Energy Resources									
Fusion - Confinement	37.0	51.8	112.0	170.0	215.0	235.0	265.0	997.0	731.0
Fusion - Laser	24.0	32.5	8.0	17.0	22.0	22.0	27.0	96.0	205.0
Solar			21.2	22.4	21.5	19.3	19.9	104.3	
Geothermal			27.2	30.7	30.1	27.3	21.6	136.9	
Total Exploit Renewable Energy Resources			168.4	240.1	288.6	303.6	333.5	1,334.2	
TOTAL ENERGY R&D PROGRAM	$	$	$ 1,062.1	$ 1,311.0	$ 1,451.4	$ 1,519.3	$ 1,618.8	$ 6,962.6	$

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
(In millions $)

Equipment Obligations	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
I. Conservation									
Reduced Consumption	$	$	$ 2.7	$ 6.2	$ 8.7	$ 4.2	$ 3.5	$ 25.3	$
Increased Efficiency			20.5	41.2	49.0	46.2	47.2	204.1	
Total Conservation			23.2	47.4	57.7	50.4	50.7	229.4	
II. Increase Production of Oil & Gas									
Production			5.7	18.9	11.9	7.9	4.3	48.7	
Resource Assessment			2.7	3.2	4.3	6.0	6.3	22.5	
Total Increase Production of Oil & Gas			8.4	22.1	16.2	13.9	10.6	71.2	
III. Substitute Coal for Oil & Gas									
Mining			13.0	16.0	18.5	22.5	30.0	100.0	
Direct Combustion			5.1	6.6	9.4	10.2	15.1	46.4	
High BTU Gasification			1.5	1.0	--	--	--	2.5	
Coal Liquefaction			5.0	7.0	5.0	6.0	10.0	33.0	
Low BTU Gasification			1.0	1.7	2.0	--	1.0	5.7	
Synthetic Fuels - Industry Pioneering			4.0	4.5	5.0	5.5	6.0	25.0	
Environmental Control Technology			10.0	5.0	4.0	4.0	5.0	28.0	
Supporting R&D			2.0	2.0	2.5	3.0	3.0	12.5	
Total Substitute Coal for Oil & Gas			41.6	43.8	46.4	51.2	70.1	253.1	
IV. Validate The Nuclear Option									
Safety and Other	2.7	2.3	13.8	7.1	8.4	8.9	8.9	47.1	26.5
Uranium Enrichment	2.2	1.7	5.1	4.8	6.4	6.4	6.4	29.1	20.2
High Temperature Gas Reactor	0.1	0.4	1.2	1.4	1.4	1.6	1.7	7.3	1.6
Light Water Self-Sustaining Reactor	0.7	5.3	0.3	0.3	0.5	0.5	0.5	2.1	2.1
Liquid Metal Fast Breeder Reactor	9.9	11.8	23.4	33.3	27.4	29.6	40.7	154.4	122.7
Gas Cooled Fast Breeder	--	--	1.0	1.6	2.2	2.8	3.4	11.0	--
Advanced Technology	--	--	0.4	0.7	1.3	1.6	1.6	5.6	--
Total Validate The Nuclear Option	15.6	21.5	45.2	49.2	47.6	51.4	63.2	256.6	173.1
V. Exploit Renewable Energy Resources									
Fusion - Confinement	2.5	3.8	23.0	49.0	24.0	58.0	35.0	189.0	133.5
Fusion - Laser	2.0	3.4	2.0	3.0	3.0	3.0	3.0	14.0	23.6
Solar			8.3	11.6	11.0	10.1	14.6	55.6	--
Geothermal			9.0	7.3	5.4	4.4	3.1	29.2	--
Total Exploit Renewable Energy Resources			42.3	70.9	43.4	75.5	55.7	287.8	157.1
TOTAL EQUIPMENT OBLIGATIONS ENERGY R&D PROGRAM	$	$	$160.7	$ 233.4	$ 211.3	$ 242.4	$ 250.3	$1098.1	

Summary Schedule
FY 1975-1979 Recommended Energy R&D Program
(In millions $)

Construction Obligations	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
I. Conservation									
Reduced Consumption	$	$	$ 0.6	$ 3.2	$ 4.6	$ 3.6	$ 1.8	$ 13.8	$
Increased Efficiency			3.6	26.7	39.2	51.4	52.3	173.2	
Total Conservation			4.2	29.9	43.8	55.0	54.1	187.0	
II. Increase Production of Oil & Gas									
Production			-	-	-	-	-	-	
Resource Assessment			2.5	-	0.5	-	-	3.0	
Total Increase Production of Oil & Gas			2.5	-	0.5	-	-	3.0	
III. Substitute Coal for Oil & Gas									
Mining			3.5	6.5	9.5	13.0	6.5	39.0	
Direct Combustion			12.1	10.0	19.7	21.4	22.6	85.8	
High BTU Gasification			21.0	50.0	45.0	32.0	4.0	152.0	
Coal Liquefaction			18.0	30.0	32.0	29.0	20.0	129.0	
Low BTU Gasification			25.2	30.3	33.0	38.0	28.0	154.5	
Synthetic Fuels - Industry Pioneering			50.0	50.0	-	-	-	100.0	
Environmental Control Technology			18.0	20.0	16.0	11.0	1.0	66.0	
Supporting R&D			-	-	-	-	-	-	
Total Substitute Coal for Oil & Gas			147.8	196.8	155.2	144.4	82.1	726.3	
IV. Validate The Nuclear Option									
Safety and Other	2.3	4.0	2.0	30.0	30.0	44.0	50.0	156.0	143.3
Uranium Enrichment	22.9	24.0	15.0	3.0	3.0	3.0	3.0	27.0	99.1
High Temperature Gas Reactor	-	-	18.0	22.0	-	-	-	40.0	40.0
Light Water Self-Sustaining Reactor	-	-	-	-	-	-	-	-	-
Liquid Metal Fast Breeder Reactor	38.5	104.5	150.0	144.0	103.0	104.0	83.0	584.0	434.0
Gas Cooled Fast Breeder	-	-	3.0	-	-	-	-	3.0	3.0
Advanced Technology	-	-	-	-	-	-	-	-	-
Total Validate The Nuclear Option	63.7	132.5	188.0	199.0	136.0	151.0	136.0	810.0	719.4
V. Exploit Renewable Energy Resources									
Fusion - Confinement	0.2	0.2	-	11.0	22.0	45.0	76.0	154.0	267.5
Fusion - Laser	9.1	7.0	-	-	-	-	-	-	100.8
Solar			3.0	5.9	8.9	12.8	9.5	40.1	
Geothermal			3.8	3.0	5.3	4.0	2.8	18.9	
Total Exploit Renewable Energy Resources			6.8	19.9	36.2	61.8	88.3	213.0	
TOTAL ENERGY R&D PROGRAM	$	$	$ 349.3	$ 445.6	$ 371.7	$ 412.2	$ 360.5	$ 1,939.3	$

Summary Schedule

FY 1975-1979 Recommended Supporting Program

(In millions $)

	President's Message		FY 1975-79 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses									
VI. Supporting Programs									
Environmental Research	$	$	$ 88.5	$ 98.5	$ 111.0	$ 125.7	$ 137.1	$ 560.8	$
Basic Research			39.0	52.1	59.6	60.7	59.2	270.6	
Manpower Development			5.0	9.0	12.5	12.3	11.2	50.0	
			132.5	159.6	183.1	198.7	207.5	881.4	
Equipment									
Supporting Programs									
Environmental Research			5.9	9.9	10.5	18.7	6.2	51.2	
Basic Research			4.0	5.9	6.4	6.3	6.8	29.4	
Manpower Development			-	-	-	-	-	-	
			9.9	15.8	16.9	25.0	13.0	80.6	
Construction									
Supporting Programs									
Environmental Research			11.5	13.5	7.0	3.0	3.0	38.0	
Basic Research			-	-	-	-	-	-	
Manpower Development			-	-	-	-	-	-	
			11.5	13.5	7.0	3.0	3.0	38.0	
TOTAL SUPPORTING PROGRAMS	$	$	$ 153.9	$ 188.9	$ 207.0	$ 226.7	$ 223.5	$1,000.0	$

I. Conservation
Reduced Consumption
End-use Conservation
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency
	1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Operating Expenses									
Energy Conservation in Buildings	$	$	$ 5.1	$ 7.1	$ 7.7	$ 8.0	$ 9.8	$ 37.7	$
Energy Conservation in Industrial Sector			5.1	5.5	6.0	8.9	9.9	35.4	
Energy Conservation in Transportation			1.8	4.2	4.5	3.0	1.5	15.0	
Integrated Utility Systems			2.6	2.0	2.0	.7	.5	7.8	
Cross Energy Sector Studies			2.0	3.5	4.0	3.0	2.5	15.0	
			16.6	22.3	24.2	23.6	24.2	110.9	
Equipment									
Energy Conservation in Buildings			.9	1.7	1.9	2.0	1.4	7.9	
Energy Conservation in Industrial Sector			.3	2.0	5.3	2.1	2.1	11.8	
Integrated Utility Systems			1.5	2.5	1.5	.1	--	5.6	
			2.7	6.2	8.7	4.2	3.5	25.3	
Construction (TEC)									
Industrial Sector Demonstration Facilities (7.8)			--	1.5	2.7	1.8	1.8	7.8	
Miscellaneous Support Facilities			.6	1.7	1.9	1.8	--	6.0	
			.6	3.2	4.6	3.6	1.8	13.8	
TOTAL END-USE CONSERVATION	$ 6.8	$ 15.5	$ 19.9	$ 31.7	$ 37.5	$ 31.4	$ 29.5	$ 150.0	$ 5.0

I. Conservation
Reduced Consumption
Improved Management
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses									
Energy Data Base Development and System Modeling	$	$	$ 3.0	$ 3.0	$ 4.0	$ 3.0	$ 3.0	$ 16.0	$
Technology Assessment of Emerging Energy Systems			2.0	2.0	4.0	4.0	2.0	14.0	
Evaluation Criteria for Energy Systems			2.0	2.0	1.0	1.0	1.0	7.0	
Systematic Management Analysis of Alternative Energy Futures			3.0	5.0	5.0	5.0	5.0	23.0	
			10.0	12.0	14.0	13.0	11.0	60.0	
Equipment									
Construction									
TOTAL IMPROVED MANAGEMENT	$ 5.3	$ 6.8	$ 10.0	$ 12.0	$ 14.0	$ 13.0	$ 11.0	$ 60.0	$ 10.0

I. Conservation
Increased Conversion and Distribution Efficiency
High Temperature Gas Turbine
(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Direct Cycle Gas Turbine		$	$	$ 3.0	$ 3.5	$ 4.0	$ 4.0	$ 4.5	$ 19.0	$
High Temperature Gas and Steam Turbine Combined Cycle										
Design and Testing of Turbines				5.0	14.0	28.0	15.0	11.0	73.0	
Design Specs. 100 MW Demo Plant				1.0	2.0	1.0	--	--	4.0	
Closed Gas Turbines to Supply Waste Heat										
Design, Specs., Test 2-3 MW Power Plant				0.5	1.0	1.0	1.0	1.0	4.5	
Procure additional power plants for use by HUD				--	--	1.5	2.0	9.0	12.5	
				9.5	20.5	35.5	22.0	25.5	113.0	
Equipment				7.3	22.3	12.3	15.3	10.3	67.5	
Construction	(TEC)									
Direct Cycle Gas Turbine Demo Plant	(69.5)			--	10.0	18.0	22.5	19.0	69.5	
High Temperature Gas Turbine Test Fac.	(10.0)			--	3.0	3.0	2.5	1.5	10.0	
Waste Heat Closed-Cycle Test Fac.	(4.0)			--	2.0	2.0	--	--	4.0	
Heat Transfer Test Facility	(3.5)			0.5	1.0	1.0	0.5	0.5	3.5	
High Temperature Combustor Facility	(1.5)			--	1.5	--	--	--	1.5	
Rotor Dynamics Test Facility	(1.5)			--	--	1.5	--	--	1.5	
Construction of 100 MW Demonstration Plt.	(32.0)			--	3.0	3.5	10.5	15.0	32.0	
Construction of 2-3 MW Demonstration Plt.	(10.0)			--	3.0	2.0	3.0	2.0	10.0	
Misc. Construction				1.0	0.5	0.5	0.5	--	2.5	
				1.5	24.0	31.5	39.5	38.0	134.5	
TOTAL HIGH TEMPERATURE GAS TURBINE		$ --	$ --	$ 18.3	$ 66.8	$ 79.3	$ 76.8	$ 73.8	$ 315.0	$

I. Conservation
Increased Conversion and Distribution Efficiency
Advanced Cycles, Fuel Cells and Other
(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Potassium Topping Cycle and Magnetohydrodynamics..		$	$	$ 5.0	$ 10.0	$ 8.5	$ 7.0	$ 7.5	$ 38.0	$
Fuel Cells..................................				4.8	6.9	8.7	14.3	20.0	54.7	
Use of Wastes as Fuels......................				.7	1.4	1.1	.9	.7	4.8	
Advanced Concepts...........................				1.8	1.9	1.9	1.9	1.9	9.4	
Enabling Technology.........................				1.8	2.7	4.3	4.3	4.3	17.4	
				14.1	22.9	24.5	28.4	34.4	124.3	
Equipment										
Potassium Topping Cycle and Magnetohydrodynamics..				2.0	4.5	14.5	8.5	9.5	39.0	
Fuel Cells..................................				--	2.5	7.8	6.1	6.2	22.6	
Use of Wastes as Fuels......................				.8	1.2	1.2	1.0	1.0	5.2	
Advanced Concepts...........................				.2	.1	.1	.1	.1	.6	
Enabling Technology.........................				.2	.3	.7	.7	.7	2.6	
				3.2	8.6	24.3	16.4	17.5	70.0	
Construction	(TEC)									
Potassium Topping Cycle 30 MWE Pilot Plant..	(13.0)			--	--	3.0	5.0	5.0	13.0	
Miscellaneous Fuel Cells Support Facs......	(2.7)			.7	.1	.5	.6	.8	2.7	
				.7	.1	3.5	5.6	5.8	15.7	
TOTAL ADVANCED CYCLE, FUEL CELLS AND OTHER..........		$ 15.1	$ 10.8	$ 18.0	$ 31.6	$ 52.3	$ 50.4	$ 57.7	$210.0	

I. Conservation
Increased Conversion and Distribution Efficiency
Advanced Auto Propulsion
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating									
Current Auto and Track Systems Improvement	$	$	$ 11.0	$ 7.0	$ 5.0	$ 5.0	$ 3.0	$ 31.0	$
New PROPULSION Systems Development									
Heat Engine Systems Development			34.0	38.0	39.0	50.0	38.0	199.0	
Electric Propulsion System Development			3.0	4.0	4.0	5.0	6.0	22.0	
Study of Non-Petroleum Energy			3.0	7.0	7.0	7.0	7.0	31.0	
			51.0	56.0	55.0	67.0	54.0	283.0	
Equipment			2.0	3.0	4.0	4.0	4.0	17.0	
Construction			--	--	--	--	--	--	
TOTAL ADVANCED AUTO PROPULSION	$ 19.8	$ 22.7	$ 53.0	$ 59.0	$ 59.0	$ 71.0	$ 58.0	$ 300.0	$

I. Conservation
Increased Conversion and Distribution Efficiency
Rail, Bus, Ship and Air Systems
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency
	1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Operating Expenses									
Rail and Bus									
System and Analytical Studies	$	$	$ 1.0	$ 1.0	$ 1.3	$ 2.0	$ 2.0	$ 7.3	$
Integrated Bus Transit System Demonstration			3.0	3.0	3.0	4.0	3.4	16.4	
Ship									
Nuclear Powered Ship			5.0	5.3	1.2	.6	.4	12.5	
Ship Hull and Propeller Efficiencies			.6	.7	.5	3.8	5.0	10.6	
Alternate Near Term Propulsion Systems			.3	1.8	2.4	.6	.3	5.4	
Air									
Operational Economies			2.5	4.0	--	--	--	6.5	
New Propulsion Systems			2.0	4.5	12.5	17.5	30.0	66.5	
Alternate Fuels			.5	1.0	.5	.5	--	2.5	
Transport Aircraft Design			3.0	4.0	10.5	12.0	24.0	53.5	
Unconventional Systems			2.0	5.0	2.0	--	--	9.0	
			19.9	30.3	33.9	41.0	65.1	190.2	
Equipment									
Rail and Bus			--	1.3	2.0	3.0	5.0	11.3	
Ship			.1	.4	.1	.8	1.1	2.5	
Air			--	.5	.5	--	--	1.0	
			.1	2.2	2.6	3.8	6.1	14.8	
Construction			--	--	--	--	--	--	
TOTAL RAIL, BUS, SHIP AND AIR SYSTEMS	$	$	$ 20.0	$ 32.5	$ 36.5	$44.8	$ 71.2	$ 205.0	$

I. Conservation
Increased Conversion and Distribution Efficiency
Energy and Fuel Transportation, Distribution and Storage

(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Overhead Transmission and Distribution		$	$	$ 1.5	$ 4.0	$ 5.1	$ 5.5	$ 7.6	$ 23.7	$
Underground Transmission and Distribution				3.8	5.1	5.3	6.5	8.0	28.7	
Storage				3.5	5.9	7.5	7.5	7.5	31.9	
Systems Development and Control				1.9	2.8	3.0	2.3	2.9	12.9	
Ship Delivery System				7.0	8.0	9.0	10.0	11.0	45.0	
				17.7	25.8	29.9	31.8	37.0	142.2	
Equipment										
Overhead Transmission and Distribution				6.1	2.4	1.5	.5	.5	11.0	
Underground Transmission and Distribution				1.0	1.5	1.5	2.0	2.2	8.2	
Storage				.6	.8	2.2	2.0	3.0	8.6	
Systems Development and Control				.2	.4	.6	.2	.6	2.0	
Ship Delivery System				--	--	--	2.0	3.0	5.0	
				7.9	5.1	5.8	6.7	9.3	34.8	
Construction	(TEC)									
Overhead 1100 KV AC Line Prototype	(1.6)			--	--	--	.8	.8	1.6	
100 MW DC Terminal Prototype	(1.5)			.3	.6	.4	.2	--	1.5	
Other Overhead Transmission Support Facilities	(1.9)			.2	.4	.4	.4	.5	1.9	
Underground Rigid AC Superconducting Line Demonstration	(1.3)			--	.2	.3	.4	.4	1.3	
Other Underground Transmission Support Facilities	(4.4)			.5	.7	.7	1.1	1.4	4.4	
10 MW hr Prototype Storage Facility	(10.0)			.1	.2	1.5	2.5	3.5	7.8	
Other Storage Support Facilities	(2.6)			--	.1	.5	.5	1.5	2.6	
Systems Development Miscellaneous Construction				.3	.4	.4	.4	.4	1.9	
				1.4	2.6	4.2	6.3	8.5	23.0	
TOTAL ENERGY AND FUEL TRANSPORTATION, DISTRIBUTION AND STORAGE		$ 5.8	$ 6.5	$ 27.0	$ 33.5	$ 39.9	$ 44.8	$ 54.8	$ 200.0	$

II. Increase Production of Oil and Gas

Production

(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79
	1973	1974	1975	1976	1977	1978	1979	1975-79	Program
Operating Expenses									
Secondary and Tertiary Recovery - Fluid Injection..	$	$	$ 6.7	$ 14.0	$ 17.2	$ 8.5	$ 4.3	$ 50.7	$
Stimulation									
Conventional			5.4	16.9	9.4	4.7	2.1	38.5	
Nuclear			3.0	12.7	12.6	11.2	13.5	53.0	
In Situ Shale Processing									
Conventional			4.0	16.9	16.0	15.6	15.6	68.1	
Nuclear			4.3	8.0	9.0	10.5	9.5	41.3	
Advanced Drilling			2.6	1.7	3.4	1.1	0.9	9.7	
			26.0	70.2	67.6	51.6	45.9	261.3	
Equipment									
Secondary and Tertiary Recovery - Fluid Injection..			4.0	8.4	3.3	3.5	0.5	19.7	
Stimulation									
Conventional			0.3	0.7	0.3	0.2	0.1	1.6	
Nuclear			0.4	0.9	0.9	0.5	0.5	3.2	
In Situ Shale Processing									
Conventional			0.5	4.0	1.2	1.5	1.1	8.3	
Nuclear			0.5	1.1	4.5	2.0	2.0	10.1	
Advanced Drilling			--	3.8	1.7	0.2	0.1	5.8	
			5.7	18.9	11.9	7.9	4.3	48.7	
Construction			--	--	--	--	--	--	
TOTAL PRODUCTION	$ 12.8	$ 11.2	$ 31.7	$ 89.1	$ 79.5	$ 59.5	$ 50.2	$ 310.0	$ 50.0

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II. Increase Production of Oil and Gas
Resource Assessment
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses									
Petroleum and Natural Gas	$	$	$ 2.9	$ 6.6	$ 9.9	$ 16.0	$ 17.6	$ 53.0	$
Uranium and Thorium			5.7	6.1	7.2	8.0	9.0	36.0	
Coal			2.7	3.6	4.1	4.0	3.6	18.0	
Oil Shale			0.9	0.9	0.9	0.9	0.9	4.5	
Non-Fuel Resources			0.9	0.9	0.9	0.9	0.9	4.5	
General Exploration			1.7	1.7	1.7	1.7	1.7	8.5	
			14.8	19.8	24.7	31.5	33.7	124.5	
Equipment									
Petroleum and Natural Gas			1.3	1.7	2.6	4.0	4.4	14.0	
Uranium and Thorium			0.6	0.6	0.8	1.0	1.0	4.0	
Coal			0.3	0.4	0.4	0.5	0.4	2.0	
Oil Shale			0.1	0.1	0.1	0.1	0.1	0.5	
Non-Fuel Resources			0.1	0.1	0.1	0.1	0.1	0.5	
General Exploration			0.3	0.3	0.3	0.3	0.3	1.5	
			2.7	3.2	4.3	6.0	6.3	22.5	
Construction (TEC)									
One Oceanographic Vessel (3.0)			2.5	--	0.5	--	--	3.0	
TOTAL RESOURCE ASSESSMENT	$ 7.2	$ 8.3	$ 20.0	$ 23.0	$ 29.5	$ 37.5	$ 40.0	$ 150.0	$ 40.0

III. Substitute Coal for Oil and Gas

Mining

(In millions $)

	(TEC)	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Surface		$	$	$ 5.5	$ 5.0	$ 4.5	$ 5.0	$ 7.0	$ 27.0	$
Underground				19.5	28.0	30.0	35.0	35.0	147.5	
Shale				3.5	1.5	1.5	1.5	3.5	11.5	
				28.5	34.5	36.0	41.5	45.5	186.0	
Equipment										
Surface				0.5	1.5	4.0	6.0	8.0	20.0	
Underground				12.0	14.0	14.0	15.0	20.0	75.0	
Shale				0.5	0.5	0.5	1.5	2.0	5.0	
				13.0	16.0	18.5	22.5	30.0	100.0	
Construction										
Four Demonstration Mines	(18.0)			--	2.0	5.0	8.0	3.0	18.0	
Long Wall Prop. Test Facility/Roof Simulator	(3.5)			3.5	--	--	--	--	3.5	
Deep Shaft Support Facility	(6.0)			--	2.0	2.5	1.5	--	6.0	
Miscellaneous				--	2.5	2.0	3.5	3.5	11.5	
				3.5	6.5	9.5	13.0	6.5	39.0	
TOTAL MINING		$ 5.9	$ 9.9	$ 45.0	$ 57.0	$ 64.0	$ 77.0	$ 82.0	$ 325.0	$

III. Substitute Coal for Oil and Gas
Direct Combustion
(In millions $)

	TEC	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Fluidized Bed Combustion										
Pressurized Fluid Bed		$	$	$ 6.0	$ 7.5	$ 5.0	$ 5.4	$ 5.4	$ 29.3	$
Atmospheric Fluid Bed				3.0	2.4	2.0	2.7	3.5	13.6	
Modification of Conventional Boilers				2.6	7.5	3.4	4.1	4.3	21.9	
Supporting R&D Research				1.2	1.0	0.5	0.2	0.1	3.0	
				12.8	18.4	10.9	12.4	13.3	67.8	
Equipment				5.1	6.6	9.4	10.2	15.1	46.4	
Construction										
Atmospheric Pilot Plant	(3.0)			3.0	--	--	--	--	3.0	
Pressurized Pilot Plant	(12.0)			4.0	4.0	4.0	--	--	12.0	
Direct Turbine Drive Pilot Plant	(7.5)			2.5	3.0	2.0	--	--	7.5	
Pressurized Boiler	(27.0)			2.6	3.0	5.0	6.4	10.0	27.0	
Pressurized Demonstration Plant	(36.3)			--	--	8.7	15.0	12.6	36.3	
				12.1	10.0	19.	21.4	22.6	85.8	
TOTAL DIRECT COMBUSTION		$ 1.9	$ 10.1	$ 30.0	$ 35.0	$ 40.0	$ 44.0	$ 51.0	$ 200.0	$

III. Substitute Coal for Oil and Gas

High Btu Gasification

(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
		1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses										
Hygas Process		$	$	$ 3.7	$ 7.3	$ 7.0	$ 8.0	$ 2.0	$ 28.0	$
CO_2 - Acceptor Process				6.5	7.3	6.0	6.0	4.0	29.8	
Synthane Process				2.3	6.4	9.0	7.0	3.5	28.2	
Bi-gas Process				--	3.0	4.0	5.0	3.5	15.5	
Demonstration Plant #1 (Coop with Industry)				--	--	20.0	20.0	35.0	75.0	
Demonstration Plant #2 (Coop with Industry)				--	--	1.0	3.0	5.0	9.0	
				12.5	24.0	47.0	49.0	53.0	185.5	
Equipment				1.5	1.0	--	--	--	2.5	
Construction	(TEC)									
Hygas Pilot Plant	(11.0)			2.0	3.0	4.0	2.0	--	11.0	
Carbon Dioxide Acceptor Pilot Plant	(2.0)			2.0	--	--	--	--	2.0	
Synthane Pilot Plant	(17.0)			8.0	7.0	2.0	--	--	17.0	
Bi-gas Pilot Plant	(21.0)			9.0	12.0	--	--	--	21.0	
Demonstration Plant	(101.0)			--	28.0	39.0	30.0	4.0	101.0	
				21.0	50.0	45.0	32.0	4.0	152.0	
TOTAL HIGH BTU GASIFICATION		$ 27.1	$ 31.4	$ 35.0	$ 75.0	$ 92.0	$ 81.0	$ 57.0	$ 340.0	$

III. Substitute Coal for Oil and Gas

Coal Liquefaction

(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency
		1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Operating Expenses										
Extraction Process		$	$	$ 9.0	$ 6.0	$ 5.0	$ 5.0	$ --	$ 25.0	$
Direct Hydrogenation				16.0	13.0	19.0	20.0	20.0	88.0	
Supporting Research				19.0	14.0	9.0	10.0	18.0	70.0	
Prototype/Demonstration Plant				8.0	5.0	5.0	5.0	7.0	30.0	
				52.0	38.0	38.0	40.0	45.0	213.0	
Equipment				5.0	7.0	5.0	6.0	10.0	33.0	
Construction	(TEC)									
Solvent Refined Coal Pilot Plant	(4.0)			4.0	--	--	--	--	4.0	
H-Coal Pilot Plant	(49.0)			8.0	20.0	18.0	3.0	--	49.0	
Advanced Process Pilot Plant	(53.0)			--	2.0	8.0	23.0	20.0	53.0	
Multiple Process Pilot Plant	(23.0)			6.0	8.0	6.0	3.0	--	23.0	
				18.0	30.0	32.0	29.0	20.0	129.0	
TOTAL COAL LIQUEFACTION		$ 11.5	$ 30.4	$ 75.0	$ 75.0	$ 75.0	$ 75.0	$ 75.0	$ 375.0	$

III. Substitute Coal for Oil and Gas
Low Btu Gasification
(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses		$	$	$ 3.8	$ 5.0	$ 7.0	$ 10.0	$ 14.0	$ 39.8	$
Equipment				1.0	1.7	2.0	--	1.0	5.7	
Construction	(TEC)									
Entrained Bed Demonstration Plant	(56.0)			10.0	10.0	10.0	16.0	10.0	56.0	
Entrained Atmospheric Pilot Plant	(9.0)			2.0	3.0	4.0	--	--	9.0	
Fluidized Atmospheric Pilot Plant	(6.0)			2.0	2.0	2.0	--	--	6.0	
Fixed Bed Pilot Plant	(19.2)			6.2	5.0	3.0	3.0	2.0	19.2	
Suspension Bed Pilot Plant	(8.0)			2.0	2.0	3.0	1.0	--	8.0	
Slurry Gasifier	(29.0)			2.0	3.0	4.0	10.0	10.0	29.0	
High Temperature Clean-up Salt	(17.0)			1.0	3.0	4.0	5.0	4.0	17.0	
High Temperature Clean-up Dolomite	(10.3)			--	2.3	3.0	3.0	2.0	10.3	
				25.2	30.3	33.0	38.0	28.0	154.5	
TOTAL LOW BTU GASIFICATION		$ 4.4	$ 22.5	$ 30.0	$ 37.0	$ 42.0	$ 48.0	$ 43.0	$ 200.0	$

III. Substitute Coal for Oil and Gas
Synthetic Fuels - Industry Pioneering
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses	$	$	$ 46.0	$ 45.5	$ 50.0	$ 44.5	$ 44.0	$ 230.0	$
Equipment			4.0	4.5	5.0	5.5	6.0	25.0	
Construction 2 Demonstration Plants (Joint funding with industry)			50.0	50.0	--	--	--	100.0	
TOTAL SYNTHETIC FUELS - INDUSTRY PIONEERING	$	$	$100.0	$100.0	$ 55.0	$ 50.0	$ 50.0	$ 355.0	$

III. Substitute Coal for Oil and Gas
Environmental Control Technology
(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
		1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses										
In Situ Coal Gasification		$	$	$ 3.5	$ 3.5	$ 4.0	$ 4.5	$ 4.5	$ 20.0	$
Flue Gas Desulfurization				12.0	7.0	3.0	3.0	3.0	28.0	
Particulate & Hazardous Emission Control				5.5	3.5	3.0	6.0	10.0	28.0	
Fuel Cleaning				4.0	2.0	3.0	3.0	5.5	17.5	
Fuel Conversion Control				9.0	6.0	5.0	8.0	13.0	41.0	
Waste Disposal				8.0	3.0	4.0	5.5	11.0	31.5	
				42.0	25.0	22.0	30.0	47.0	166.0	
Equipment				10.0	5.0	4.0	4.0	5.0	28.0	
Construction	(TEC)									
Flue Gas Desulfurization	(26.0)			10.0	14.0	2.0	--	--	26.0	
Particulate & Hazardous Emission Control Pilot Plant	(20.0)			--	5.0	10.0	5.0	--	20.0	
Fuel Cleaning Pilot Plant	(10.0)			8.0	1.0	1.0	--	--	10.0	
Fuel Conversion Control Demo Plant	(10.0)			--	--	3.0	6.0	1.0	10.0	
				18.0	20.0	16.0	11.0	1.0	66.0	
TOTAL ENVIRONMENTAL CONTROL TECHNOLOGY		$ 32.5	$ 51.5	$ 70.0	$ 50.0	$ 42.0	$ 45.0	$ 53.0	$ 260.0	$

III. Substitute Coal for Oil and Gas
Supporting R&D
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses	$	$	$ 18.0	$ 20.0	$ 21.5	$ 24.0	$ 24.0	$ 107.5	$
Equipment			2.0	2.0	2.5	3.0	3.0	12.5	
Construction			--	--	--	--	--	--	
TOTAL SUPPORTING R&D	$ 5.5	$ 11.4	$ 20.0	$ 22.0	$ 24.0	$ 27.0	$ 27.0	$ 120.0	$

(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79
	(TEC)	1973	1974	1975	1976	1977	1978	1979	1975-79	Program
Operating Expenses										
Reactor Safety Research		$ 33.9	$ 37.9	$ 57.8	$ 67.5	$ 81.6	$ 91.6	$101.6	$400.1	$344.3
Waste Management		3.5	5.9	10.5	12.0	12.0	14.0	15.0	63.5	47.3
Dry Cooling Towers		.3	1.3	4.5	6.5	8.0	9.0	10.5	38.5	48.5
Nuclear Facility Siting		--	--	2.0	2.5	3.0	3.0	3.5	14.0	--
		37.[illegible]	45.1	74.8	88.5	104.6	117.6	130.6	516.1	440.1
Equipment										
Reactor Safety										
General Equipment		2.6	2.3	2.6	5.6	6.7	7.0	7.0	28.9	22.0
Computers		--	--	10.0	--	--	--	--	10.0	--
Waste Management		.1	.3	1.0	1.0	1.2	1.2	1.2	5.6	4.5
Dry Cooling Towers				.2	.5	.5	.7	.7	2.6	--
		2.[illegible]	2.6	13.8	[illegible].1	8.4	8.9	8.9	47.1	26.5
Construction										
Reactor Safety										
Reactor Modifications		2.3	4.0	2.0	10.0	10.0	4.0	5.0	31.0	61.3
Waste Management										
Retrievable Surface Storage Facility	(40)				5.0	10.0	15.0	5.0	35.0	35.0
HLW Solidification Pilot Plant	(3)				3.0	--	--	--	3.0	
HLW Solidification Demo Plant (Coop)	(10)					5.0	5.0	--	10.0	
Bedded Salt Pilot Plant	(45)					5.0	15.0	15.0	35.0	35.0
Transuranic Partition Pilot Plant	(15)						5.0	10.0	15.0	
Transuranic Partition Demo Plant	(25)							10.0	10.0	
Solid Alpha Waste Demo Plant	(50)							5.0	5.0	
Dry Cooling Towers										
Test Facility	(12)				12.0				12.0	12.0
		2.3	4.0	2.0	30.0	30.0	44.0	50.0	156.0	145.3
TOTAL REACTOR SAFETY & OTHER		$ 42.[illegible]	$ 51.7	$ 90.6	$125.6	$143.0	$170.5	$189.5	$[illegible]	$609.9

IV. Validate the Nuclear Option
Uranium Enrichment
(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses		$ 25.2	$ 31.1	$ 44.1	$ 47.0	$ 48.0	$ 49.0	$ 50.0	$238.1	$165.2
Equipment		2.2	1.7	5.1	4.8	6.4	6.4	6.4	29.1	20.2
Construction	(TEC)									
Gas Centrifuge										
Component Test Facility	(27.4)	6.1	16.0	5.0					5.0	5.0
Component Preparation Laboratories	(30.0)	16.4	7.0	3.0					3.0	3.0
CPL Retooling	(5.0)			5.0					5.0	5.0
Demonstration Centrifuge Facility	(70.0)			--	--	--	--	--	--	70.0
GPP and Misc. Projects		.4	1.0	2.0	3.0	3.0	3.0	3.0	14.0	16.1
		22.9	24.0	15.0	3.0	3.0	3.0	3.0	27.0	99.1
TOTAL URANIUM ENRICHMENT		$ 50.3	$ 56.8	$ 64.2	$ 54.8	$ 57.4	$ 58.4	$ 59.4	$294.2	$284.5

IV. Validate the Nuclear Option
High Temperature Gas Reactor
(In millions $)

	(TEC)	President's Message 1973	1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
HTGR Base Program		$ 5.1	$ 9.3	$ 11.0	$ 12.0	$ 14.0	$ 16.5	$ 17.5	$ 71.0	$ 57.0
Thorium Utilization		2.0	4.5	9.8	9.3	8.8	8.8	8.8	45.5	30.0
		7.1	13.8	20.8	21.3	22.8	25.3	26.3	116.5	87.0
Equipment										
HTGR Program		.1	.4	.6	.8	1.1	1.3	1.5	5.3	1.0
Thorium Utilization		--	--	.6	.6	.3	.3	.2	2.0	.6
		.1	.4	1.2	1.4	1.4	1.6	1.7	7.3	1.6
Construction										
Reprocessing Pilot Plant	(30.0)	--	--	15.0	15.0				30.0	30.0
Refabrication Pilot Plant	(10.0)	--	--	3.0	7.0				10.0	10.0
		--	--	18.0	22.0	--	--	--	40.0	40.0
TOTAL HIGH TEMPERATURE GAS REACTOR		$ 7.2	$ 14.2	$ 40.0	$ 44.7	$ 24.2	$ 26.9	$ 28.0	$163.8	$128.6

IV. Validate the Nuclear Option
Light Water Self-Sustaining Reactor
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses	$28.8	$23.7	$21.1	$17.4	$ 9.3	$ 9.3	$ 9.3	$66.4	$66.4
Equipment	.7	5.3	.3	.3	.5	.5	.5	2.1	2.1
Construction	--	--	--	--	--	--	--	--	--
TOTAL LIGHT WATER SELF-SUSTAINING REACTOR	$29.5	$29.0	$21.4	$17.7	$ 9.8	$ 9.8	$ 9.8	$68.5	$68.5

IV. Validate the Nuclear Option
Liquid Metal Fast Breeder (LMFBR)
(In millions $)

	(TEC)	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
LMFBR Base Program		$ 143.2	$ 150.7	$ 207.0	$ 244.9	$ 247.5	$ 248.6	$ 248.6	$ 1196.6	$1096.9
LMFBR Demonstration Program		.9	20.0	14.0	17.0	22.0	19.0	--	72.0	205.0
Nuclear Safety		19.7	29.0	37.0	44.0	49.3	54.6	61.7	246.6	214.0
Technology and Engineering		41.6	40.8	45.6	55.4	61.6	68.4	72.0	303.0	398.0
		205.4	240.5	303.6	361.3	380.4	390.6	382.3	1818.2	1913.9
Equipment										
LMFBR Base Program										
Computers		--	--	--	13.0	3.0	3.0	15.0	34.0	39.0
General Equipment		5.5	7.3	15.7	12.6	15.0	16.3	14.0	73.6	43.3
Nuclear Safety		1.9	2.3	3.5	3.5	4.0	4.7	5.2	20.9	16.3
Technology and Engineering		2.5	2.2	4.2	4.2	5.4	5.6	6.5	25.9	24.1
		9.9	11.8	23.4	33.3	27.4	29.6	40.7	154.4	122.7
Construction	(TEC)									
Sodium Pump Test Facility		--	5.0	--	--	--	--	--	--	--
Fast Flux Test Facility	(420)	25.6	82.8	132.0	100.0	--	--	--	232.0	--
Transient Test Facility	(4)	--	--	4.0	--	--	--	--	4.0	4.0
General Plant Projects		5.4	5.6	7.0	8.0	8.0	8.0	9.0	40.0	55.0
Mods to Reactors		7.5	11.1	7.0	8.0	8.0	8.0	9.0	40.0	47.0
EBR-II Heat Rejection System	(38)				5.0	15.0	18.0	--	38.0	38.0
LMFBR Engineering Facility	(50)				10.0	20.0	15.0	5.0	50.0	50.0
Steam Generator Test Facility	(100)					10.0	25.0	35.0	70.0	100.0
LMFBR Advanced Fuels Lab	(30)				10.0	20.0	--	--	30.0	30.0
Transient Safety Test Facility	(30)				3.0	12.0	10.0	5.0	30.0	30.0
Safety Test Facility	(80)					10.0	20.0	20.0	50.0	80.0
		38.5	104.5	150.0	144.0	103.0	104.0	83.0	584.0	434.0
TOTAL LIQUID METAL FAST BREEDER		$ 253.8	$ 356.8	$ 477.0	$ 538.6	$ 510.8	$ 524.2	$ 506.0	$ 2556.6	$2470.6

IV. Validate the Nuclear Option
Gas Cooled Fast Breeder
(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
		1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses		$ 1.0	$ 1.0	$ 13.0	$ 21.4	$ 26.8	$ 30.2	$ 34.6	$126.0	$ 24.0
Equipment				1.0	1.6	2.2	2.8	3.4	11.0	--
Construction	(TEC)									
GCFR Core Flow Test Facility	(3)			3.0	--	--	--	--	3.0	3.0
TOTAL GAS COOLED FAST BREEDER		$ 1.0	$ 1.0	$ 17.0	$ 23.0	$ 29.0	$ 33.0	$ 38.0	$140.0	$ 27.0

IV. Validate the Nuclear Option
Advanced Technology
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses									
Advanced Fuels and Materials	$ --	$ --	$ 11.4	$ 12.6	$ 15.9	$ 17.4	$ 18.6	$ 75.9	$ --
Engineering Development	3.2	1.4	3.2	3.5	4.5	5.0	7.0	23.2	9.9
Engineering Evaluation	2.5	3.8	4.0	4.0	4.0	4.0	4.0	20.0	37.0
Molten Salt	4.6	2.0	2.0	3.0	4.0	5.0	5.0	19.0	19.0
Desalting	1.0	0.6	0.5	0.7	0.8	1.0	1.0	4.0	17.3
	11.3	7.8	21.1	23.8	29.2	32.4	35.6	142.1	83.2
Equipment	--	--	.4	.7	1.3	1.6	1.6	5.6	--
Construction	--	--	--	--	--	--	--	--	--
TOTAL ADVANCED TECHNOLOGY	$ 11.3	$ 7.8	$ 21.5	$ 24.5	$ 30.5	$ 34.0	$ 37.2	$147.7	$ 83.2

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V. Exploit Renewable Energy Resources
Fusion - Confinement Systems
(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
		1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses										
Research		$ 6.5	$ 9.9	$ 30.0	$ 35.0	$ 42.0	$ 39.0	$ 38.0	$ 184.0	$ 168.0
Development		5.0	7.0	18.0	24.0	54.0	42.0	50.0	168.0	104.1
Confinement		23.5	30.3	52.0	74.0	87.0	90.0	99.0	402.0	307.0
Technology		2.0	4.6	12.0	37.0	52.0	64.0	78.0	243.0	151.9
		37.0	51.8	112.0	170.0	215.0	235.0	265.0	997.0	731.0
Equipment										
Research										
General		.5	.7	2.0	4.0	5.0	6.0	6.0	23.0	44.9
Computers		--	--	11.0	15.0	--	25.0	--	49.0	25.0
Development		.3	.3	2.0	2.0	3.0	4.0	5.0	16.0	8.8
Confinement										
General		1.5	2.5	7.0	10.0	13.0	18.0	19.0	67.0	44.0
Power Supplies		--	--	--	18.0	--	--	--	18.0	--
Technology		.2	.3	1.0	2.0	3.0	5.0	5.0	16.0	10.8
		2.5	3.8	23.0	49.0	24.0	58.0	35.0	189.0	133.5
Construction	(TEC)									
Tokamak DT-PTR	(100)				5.0	7.0	13.0	34.0	57.0	87.0
Rotating Target Neutron Facility	(10)				3.0	5.0	2.0	--	10.0	10.0
Plasma Target Neutron Facility	(15)				2.0	7.0	6.0	--	15.0	15.0
Computer Facility Expansions	(4)			--	2.0	--	2.0	--	4.0	8.0
Facility Modifications	(4)	.2	.2		1.0	1.0	1.0	1.0	4.0	4.5
Component Development Facilities	(63)					2.0	14.0	16.0	32.0	--
Mirrow DT-PTR-FERF	(100)						7.0	18.0	25.0	69.0
Theta Pinch DT-PTR	(100)							7.0	7.0	74.0
		.2	.2	--	11.0	22.0	45.0	76.0	154.0	267.5
TOTAL FUSION - CONFINEMENT SYSTEMS		$ 39.7	$ 55.8	$ 135.0	$ 230.0	$ 261.0	$ 338.0	$ 376.0	$1340.0	$1132.0

V. Exploit Renewable Energy Resources
Fusion - Laser
(In millions $)

		President's Message		1975-1979 Energy R&D Program						Agency 1975-79
		1973	1974	1975	1976	1977	1978	1979	1975-79	Program
Operating Expenses										
Facility Design and Operation		$	$	$ .7	$ 1.4	$ 3.0	$ 3.0	$ 4.4	$ 12.5	$
New Laser Development				3.5	7.3	10.6	10.6	11.2	43.2	
Target Development				.4	1.2	1.2	1.2	1.5	5.5	
Target Experimentation				2.0	3.3	3.3	3.3	3.5	15.4	
Diagnostic Development				1.2	1.6	1.6	1.6	1.9	7.9	
Reactor Systems Studies				.2	1.7	1.8	1.8	4.0	9.5	
Other				--	.5	.5	.5	.5	2.0	
		24.0	32.5	8.0	17.0	22.0	22.0	27.0	96.0	
Equipment		2.0	3.4	2.0	3.0	3.0	3.0	3.0	14.0	
Construction	(TEC)									
Laser Fusion Lab., LASL	(5.2)	5.2	--							
Laser Fusion Lab., LLL	(6.8)	3.0	3.8							
H. E. Laser Facility, LLL	(20.0)	--	2.0							
GPP		0.9	1.2							
		9.1	7.0	--	--	--	--	--	--	
TOTAL FUSION - LASER		$ 35.1	$ 42.9	$ 10.0	$ 20.0	$ 25.0	$ 25.0	$ 30.0	$ 110.0*	$ *

*The $110 million represents the civilian portion of an on-going Laser Fusion program. The balance of the program is included in the National Security section of the AEC budget and totals $329 million over this five-year period.

V. Exploit Renewable Energy Resources
Solar
(In millions $)

		President's Message		FY 1975-1979 Energy R&D Program						Agency
		1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Operating Expenses										
Heating and Cooling of Buildings		$	$	$ 7.8	$ 8.4	$ 5.7	$ 3.5	$ 3.4	$ 28.8	$
Solar Thermal Conversion				3.8	3.8	4.8	3.4	3.0	18.8	
Wind Energy Conversion				3.2	3.2	3.2	2.7	1.9	14.2	
Ocean Thermal Conversion				1.8	2.0	2.5	3.7	3.6	13.6	
Photovoltaic Conversion				2.2	3.0	3.5	4.0	4.5	17.2	
Bioconversion				2.4	2.0	1.8	2.0	3.5	11.7	
				21.2	22.4	21.5	19.3	19.9	104.3	
Equipment										
Heating and Cooling of Buildings				5.0	5.2	5.0	3.0	3.0	21.2	
Solar Thermal Conversion				1.2	3.2	1.7	2.0	3.1	11.2	
Wind Energy Conversion				.1	.1	.1	.1	.1	.5	
Ocean Thermal Conversion				--	--	--	1.0	1.9	2.9	
Photovoltaic Conversion				2.0	2.6	3.5	4.0	6.5	18.6	
Bioconversion				--	.5	.7	--	--	1.2	
				8.3	11.6	11.0	10.1	14.6	55.6	
Construction	(TEC)									
Solar Thermal Conversion Pilot Plant	(5.5)			--	--	1.0	3.1	1.4	5.5	
Wind Energy Conversion										
5 Small-scale systems	(4.1)			1.2	1.7	1.2	--	--	4.1	
5 MW-scale systems	(5.7)			1.2	.9	1.2	1.2	1.2	5.7	
Large-scale multi-unit systems	(7.2)			.5	.8	1.5	3.5	.9	7.2	
Ocean Thermal										
Ocean Thermal Conversion Test Facility	(9.6)			.1	1.5	2.0	2.5	3.5	9.6	
Ocean Thermal Pilot Plant (Preliminary Design)	(5.0)			--	--	--	--	.5	.5	
Bioconversion										
Pilot Plant for Conversion of Agric. Residues to Methane	(3.0)			--	1.0	1.0	1.0	--	3.0	
Pilot Plant for Conversion of Wastes to Fuel	(4.5)			--	---	1.0	1.5	2.0	4.5	
				3.0	5.9	8.9	12.8	9.5	40.1	
TOTAL SOLAR		$ 4.[illegible]	$ 13.2	$ 32.5	$ 39.9	$ 41.4	$ 42.2	$ 44.0	$ 200.0	$ 80.0

V. Exploit Renewable Energy Resources
Geothermal
(In millions $)

	President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses									
Resource Assessment and Exploration	$	$	$ 7.7	$ 9.0	$ 9.0	$ 9.0	$ 8.0	$ 42.7	$
Environmental, Legal & Institutional Research			3.0	3.1	2.3	.9	.4	9.7	
Resource Utilization									
High Temperature (> 180°c) Low Salinity Convective			2.1	2.3	1.9	1.2	0.9	8.4	
High Temperature (> 180°c) High Salinity Convective			0.7	0.9	0.9	1.0	0.8	4.3	
Geopressurized Sedimentary Systems			1.1	1.3	1.3	1.0	0.8	5.5	
Low Temperature (< 180°c) Convective			1.6	1.8	1.6	1.3	1.0	7.3	
Hot Dry Rock			2.7	2.9	2.9	3.0	2.5	14.0	
Non-Electric			0.8	1.0	1.0	1.0	0.8	4.6	
Normal Geothermal Gradients			--	0.4	0.4	0.4	0.4	1.6	
Advanced Research and Technology			7.5	8.0	8.8	8.5	6.0	38.8	
			27.2	30.7	30.1	27.3	21.6	136.9	
Equipment									
Resource Assessment and Exploration			2.0	1.5	1.0	1.0	1.0	6.5	
Environmental, Legal, and Institutional Research			0.4	0.4	0.2	0.1	0.1	1.2	
Resource Utilization			4.1	3.9	3.0	2.0	1.0	14.0	
Advanced Research and Technology			2.5	1.5	1.2	1.3	1.0	7.5	
			9.0	7.3	5.4	4.4	3.1	29.2	
Construction (Demonstration Plants) (TEC)									
High Temperature - Low Salinity (3.8)			3.8	--	--	--	--	3.8	
High Temperature - High Salinity (3.8)			--	1.0	1.8	1.0	--	3.8	
Geopressurized Sedimentary Systems (3.8)			--	1.0	1.8	1.0	--	3.8	
Low Temperature Systems (3.7)			--	1.0	1.7	1.0	--	3.7	
Hot Dry Rock (3.8)			--	--		1.0	2.8	3.8	
			3.8	3.0	5.3	4.0	2.8	18.9	
TOTAL GEOTHERMAL	$ 3.8	$ 11.1	$ 40.0	$ 41.0	$ 40.8	$ 35.7	$ 27.5	$ 185.0	$ 20.0

VI. Supporting Programs
Environmental Research
(In millions $)

		President's Message 1973	President's Message 1974	FY 1975-1979 Energy R&D Program 1975	1976	1977	1978	1979	1975-79	Agency 1975-79 Program
Operating Expenses										
Pollutant Characterization, Measurement and Monitoring		$	$	$ 10.7	$ 15.8	$ 18.4	$ 18.7	$ 19.2	$ 82.8	$
Transport of Pollutants				17.0	17.0	17.0	19.0	19.0	89.0	
Health Effects				23.3	21.2	21.2	24.2	24.2	114.1	
Ecological Effects				23.5	26.5	29.4	32.8	36.7	148.9	
Social and Welfare Effects				11.0	15.0	19.0	23.0	28.0	96.0	
Environmental Assessment and Policy Formulation				3.0	3.0	6.0	8.0	10.0	30.0	
				88.5	98.5	111.0	125.7	137.1	560.8	
Equipment										
Pollutant Characterization, Measurement and Monitoring				.6	.7	.7	.7	.8	3.5	
Transport of Pollutants				2.5	6.0	6.0	4.0	.5	19.0	
Health Effects				.2	.3	.3	.3	.3	1.4	
Ecological Effects				2.6	2.9	3.5	13.7	4.6	27.3	
				5.9	9.9	10.5	18.7	6.2	51.2	
Construction	(TEC)									
Sites for Pollutant Monitoring	(10.0)			2.0	2.0	2.0	2.0	2.0	10.0	
Miscellaneous Additions and Support Facilities	(28.0)			9.5	11.5	5.0	1.0	1.0	28.0	
				11.5	13.5	7.0	3.0	3.0	38.0	
TOTAL ENVIRONMENTAL RESEARCH		$	$	$ 105.9	$ 121.9	$ 128.5	$ 147.4	$ 146.3	$ 650.0	$

VI. Supporting Programs
Basic Research
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency 1975-79 Program
	1973	1974	1975	1976	1977	1978	1979	1975-79	
Operating Expenses									
Materials	$	$	$ 7.0	$ 9.5	$ 10.5	$ 10.5	$ 10.5	$ 48.0	$
Chemical, Physical, Engineering			14.5	19.5	21.5	21.5	21.5	98.5	
Biological			11.0	13.8	15.5	16.5	16.0	72.8	
Plasmas			2.7	3.6	4.5	3.6	3.6	18.0	
Mathematical			3.8	5.7	7.6	8.6	7.6	33.3	
			39.0	52.1	59.6	60.7	59.2	270.6	
Equipment									
Materials			1.0	1.5	1.5	1.5	1.5	7.0	
Chemical, Physical, Engineering			1.5	2.5	2.5	2.5	2.5	11.5	
Biological			1.0	1.2	1.5	1.5	2.0	7.2	
Plasmas			.3	.4	.5	.4	.4	2.0	
Mathematical			.2	.3	.4	.4	.4	1.7	
			4.0	5.9	6.4	6.3	6.8	29.4	
Construction			--	--	--	--	--	--	
TOTAL BASIC RESEARCH	$	$	$ 43.0	$ 58.0	$ 66.0	$ 67.0	$ 66.0	$ 300.0	$

VI. Supporting Programs
Manpower Development
(In millions $)

	President's Message		FY 1975-1979 Energy R&D Program						Agency
	1973	1974	1975	1976	1977	1978	1979	1975-79	1975-79 Program
Operating Expenses.									
Faculty Orientation	$	$	$ 1.5	$ 2.4	$ 3.0	$ 3.0	$ 3.0	$ 12.9	$
Managerial Training and Orientation			0.5	0.6	0.5	0.5	0.4	2.5	
Student & Postgraduate Support			1.5	2.5	4.5	5.0	5.5	19.0	
Industry/Laboratory Manpower Development Program			1.5	3.5	4.5	3.8	2.3	15.6	
			5.0	9.0	12.5	12.3	11.2	50.0	
Equipment			--	--	--	--	--	--	
Construction			--	--	--	--	--	--	
TOTAL MANPOWER DEVELOPMENT	$	$	$ 5.0	$ 9.0	$ 12.5	$ 12.3	$ 11.2	$ 50.0	$

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Remarks by

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before the

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MEETING THE CHALLENGE TO NUCLEAR ENERGY HEAD-ON

Prologue

It seems that in recent months all the dire energy predictions made during the past half decade have become alarmingly true. The energy "dilemma" has evolved into the energy "crisis." No aspect of our energy supply and demand structure has been spared. No prior prediction, regardless of how extreme or irresponsibly judged when made, is without some foundation in fact today. And these depressing facts of life are made all the more dangerously true because of recent events in the Mideast.

On the other hand, never before has there been such an attitude of willingness and desire to cope realistically with the crisis. The most discussed subject in the Congress, the Executive Department, and the regulatory agencies are various alternatives for resolution of the situation.

Today I want to address one segment of the problem: namely the question of what can or should be done to streamline the process to license and build commercial nuclear reactors more expeditiously to help meet our energy requirements. To address that subject forthrightly certain facts must be squarely faced and certain issues must be identified. These facts and issues in many cases are as appalling and disquieting to the Commission as they are to the nuclear industry and the general public.

The uncomfortable fact is that despite our efforts to reverse or shorten the on-line project time for nuclear plants—the period from ordering of the plants until they begin commercial operation—that time has been lengthening and, as the President recognized in his September 10 energy message, these delays are "unreasonable." Given the present circumstances and from the public interest perspective, I would add "untenable."

The on-line project time for 10 large nuclear plants operating at the end of 1971 averaged 5-1/2 years. Today the estimated project time for current plants has been averaging about 9-10 years. While we can take some solace in the fact that comparable trends also exist for fossil fuel plants and other major construction projects, even the time required for construction of fossil fuel plants is about 25% less than for similar sized nuclear plants. Apologists will remind us that fossil fuel plants do not go through the same rigorous licensing regime as a nuclear plant. They further tell us that nuclear plants as well as fossil fuel plants are being delayed primarily because of matters not clearly controllable by government; for example, construction delays, labor problems, late delivery of components, materials shortages. I will address these matters a little later in my remarks.

Regardless of invidious comparisons, however, the fact of the matter is that nuclear as well as fossil fuel plants are

needed to meet the energy requirements of our country. The real challenge is not to attempt to justify, rationalize or explain away the delays but determine forthrightly whether the project time can be reduced, and if so how. A little additional history may be in order as we address this subject today.

The Industry's Responsibility

The nuclear industry has to be recognized as one which has experienced rapid growth in an environment characterized by an overlay of stringent quality control and regulatory requirements—a combination of factors rarely found or experienced in large-scale industrial projects in the history of the nation. And, while the technical feasibility and demonstration of the technology is a quarter of a century old, the operating experience, especially with nuclear plants of the 800-1000 MWe variety, is still quite minimal. Accordingly it is altogether natural and should have been expected that certain design changes and other technological-related fixes would be required as the normal engineering and operational mismatches were flushed out during operation. As a matter of fact, the entire commercial industry has developed essentially within the last decade and a half. Not only has the required expertise placed heavy demands on the traditional skilled labor markets, but the utility industry has had to learn to cope with new and different management and technical problems incident to commercial nuclear power. And they have done so and done so well. The remarkable growth of the technology and the industry has in no manner compromised the health and safety record of the industry; a record considered by some as undeniably one of the most remarkable achievements of the 20th century. Certainly the major hurdles of a new and evolving technology and industry are behind us. But the demands of nuclear energy continue into the future. New utilities will be joining the 66 different companies that today are or have indicated an intention to go nuclear and a sense of complacency must be avoided.

The primary responsibility of the industry now is to maintain and control its growth momentum. This obligation encompasses new and different requirements that must be identified, anticipated, and eventually managed. It requires a reassessment by this industry of its role within the energy spectrum of the country. It requires new policies, new procedures, innovation, change and decisiveness in all sectors and at all levels of the industry. There is a rapidly emerging consensus that this is true. At the same time the industry's responsibilities are evolving—so is the role of the Federal government. It should be evident that from the Government's perspective, the emphasis in the light water reactor area has dramatically shifted in recent years from research and development to regulation. And what I have just said with regard to the need for innovation and change applies equally as well to the AEC and its regulatory program. I will return to this theme with regard to new AEC approaches shortly.

Organizations and Problem Solving

In the immediate future certain rather dramatic reorganization proposals will be under Congressional consideration. The Administration has proposed a Bill to create an Energy Research and Development Administration to undertake new commitments to technology and bring to commercial fruition more established energy R&D programs. Last week the President gave added impetus to this legi ··tion in announcing project independence. It has also been proposed that the Regulatory organization of the Atomic Energy Commission be reconstituted as a Nuclear Energy Commission. Whether these proposals are ultimately enacted by the Congress this year or next, and I for one hope they are, the viability and merit of the concepts they embody do not appear in dispute.

But new organizations should not be viewed as the sole answer to the energy problem. New organizational forms are valuable in facilitating the implementation of new policies. However, they cannot become ends unto themselves as we look down the road. While we should plan for their implementation in one form or another in the future, we should nevertheless take those actions today to develop the policies to be implemented by the existing as well as new organizational structures. And there are indeed steps which can be taken by the AEC, industry, and other entities working together which can shorten not only the licensing path, but meet other policy objectives and give greater purpose to the regulatory system as well. The AEC has made the basic internal organizational changes in the past two years which are necessary to increase the efficiency of the existing licensing process. At the same time, AEC's Regulatory organization has been given the manpower and funding requirements for more concerted long-range planning and development of new policy objectives. The backlog and implementation problems of the Calvert Cliffs decision and the implementation of the National Environmental Policy Act are behind us. We have had a reasonable length of time to get our arms around the problems of environmental impact statements. But even with our successes we must admit that we "ad hoced" a response to a problem which blindsided us. The current energy and environmental crisis, I do not believe, can withstand similar treatment. We not only need to take immediate steps wherever possible, but we also need a program for the future, a program which realistically takes into account the unique contributions which nuclear can provide to the overall energy system.

Short Term Nuclear Prospects

In these days of genuine, not postulated, fuels shortage, an administration evaluation was undertaken to determine those immediate actions which might be implemented to get us "over the hump" and put us on the path to domestic energy self-sufficiency. These various studies served as the basis for last week's Presidential energy message. A significant and demanding aspect of this statement, the seventh such Presidential pronouncement within the last

year, included the President's request that AEC structure a system to reduce the current on-line time of nuclear plants to 6 years

As As part of this overall Federal study, AEC reviewed the near term prospects for accelerating the on-line times of nuclear power plants scheduled for completion by the end of 1975. I believe a brief recounting of this effort and its findings will allow you to judge for yourselves what can be expected as the nuclear contribution to the U.S. energy pool within the next several years. I would hasten to add that what follows in no way should be taken as a prejudgment of individual licensing cases which must perforce constitute the major underlying assumption of the following model.

Of the 59 nuclear plants currently under construction, 36 have been scheduled by utilities for completion before January 1976. Parenthetically, and to put these 36 in perspective, recall that the U.S. currently has 39 operable nuclear power plants. As an aside, you should know that all 36 of these plants have regulatory review schedules that will meet the AEC's avowed objective of concluding the entire licensing process (including public hearings) coincident with the completion of construction.

Twenty-one of these 36 plants have been identified by the Federal Power Commission has high priority projects which are needed to become operational early to contribute to critical power reserves through 1975. AEC's analysis indicated that construction and operational testing are more than 80% complete for 8 of these units and, hence, it would be difficult for the utilities to accelerate construction at this late stage. This leaves 13 plants on the FPC critical list which conceivably could be speeded up construction-wise. However, discussions with utility management of these 13 plants produced the consensus that no significant acceleration of construction programs was possible. The major reasons given for this consensus, far from being negative I believe, attest to the fact that utilities for the most part are exerting their best efforts in the face of some very trying hardships to bring their plants on-line on a rapid timetable: (1) most utilities are already utilizing overtime, double shifts, or incentive contracts to speed construction, and the theory of diminishing returns argues against any expansion of this program; (2) capital outlays for increased overtime (where deemed effective) have been made almost impossible due to increased interest rates; and (3) a shortage exists of qualified skilled craftsmen such as welders, pipe fitters and electricians. Finally, and most important from AEC's standpoint, any significant improvement in construction schedules without providing the necessary quality assurance resources would almost certainly result in shortcomings in quality assurance controls, a position which the AEC finds untenable.

Delays, Their Causes, and Jawboning

Even given the fact that for plants needed in the near term maximum pressure is being exerted, it has been apparent for some time to both the industry and AEC alike that delays of one kind or another have and are causing system discontinuities and do adversely impact on the availability dates of nuclear power plants. For example, the Federal Power Commission recently conducted a survey of the pacing factors causing schedule setbacks in 28 nuclear plants scheduled to become operational in 1973. The findings are presented in the following chart (Chart 1).

In reviewing this tabulation I was struck by two interesting features. First, note the varigated reasons for plant delays—I am sure many of you in the audience could add to this chart from your own experience and in words which probably would not be quite so tender to the ear. Secondly, note the wide divergency in the total months of delay due to construction and manufacturing-related problems, and regulatory-generated delays. We all know that statistics can be very tricky, but even doubling or tripling the regulatory-related delay figures does not do much to close the gap.

The foregoing should not be taken as "the word" on plant delays. As we all recognize, it is very difficult to arrive at generalities about the amount of time a plant is delayed and the relative importance of each delay factor—each plant is significantly different from another both in terms of design and the regulatory environment within which it must be licensed, and the reasons for delay are multifaceted and interconnected. Even though the nut may be hard to crack, this should not deter us from making a start at getting the cards out on the table and openly discussing them with a view toward generating possible solutions.

A dialogue on this subject, in fact, has already begun. On November 1, Chairman Ray and I met with a small number of nuclear industry executives and Roy Ash, Director of the Office of Management and Budget, and Governor John Love, Director of the President's Energy Policy Office. The industry has ably represented by William Gould, Gordon Corey, Charles Luce, Lelan Sillin, and Louis Roddis. I can candidly report that each side, in full recognition of its respective responsibilities, made forthright presentations and gave as well as it took.

Besides construction-related delays, a major topic of discussion with Messrs. Ash and Love focused on the tension between the Commission and industry involving the series of changes in licensing requirements that are summed up in the term "ratcheting."

I am sure that the industry understands that some regulatory ratcheting, like death and taxes, is unavoidable. We have, for example, recently invoked a loud click in the gears in the context of a recent change to preclude potential safety problems arising from the fact that it is possible that certain adverse reactor events could take place without the reactor shutting itself down. I doubt that anyone in industry fully acquainted with the background of this particular change in our requirements would disagree with the general position taken by the Regulatory staff. I believe that most of you understand the need for these kinds of changes in regulatory requirements and that they are not the source of your complaints.

Rather, it is the small seemingly continuous ratchets during the day-to-day review process that appear to be the cause of industry concern. Regulatory management and the Commission have for the past year recognized that there is justification for that concern and have taken steps which presumably are bringing the matter under control. Procedures have been instituted to eliminate the past practices of implementing significant ratchets at the staff review level without higher level review. The current procedures require that the staff reviewer identify the proposed change and submit it to the appropriate management level within the regulatory organization or even in some cases—where major generic matters are involved—to the Commission before implementation. In addition, all applicants will be advised in writing that senior regulatory officials are available to hear appeals from changes and other requirements imposed by staff reviewers.

We expect that these procedures will result in elimination or at least a substantial reduction of any unnecessary ratcheting. I do not expect that they will eliminate all of the complaints though because there will always be situations where industry will say that the AEC is being too conservative. In those instances I am sure the applicant will call it ratcheting. Regulatory staff will call it prudence and I want to assure you, we hope that our judgments are as realistic as possible.

The Longer Haul

Last spring when some degree of success had been obtained in getting the system moving again, the Regulatory staff at my request and with the Commission's concurrence undertook a comprehensive study of the licensing process. Its mandate was to expand its collective mind into relatively uncharted areas with a view toward expediting the licensing cycle with no loss in quality in light of projections of significantly increasing orders for nuclear power reactors. The task was divided into two phases. Phase 1 consisted of the accumulation of factual information on concepts which I will explain shortly, while Phase 2 put this raw material in the context of evaluation of the need to step up the licensing process, appraisal of the need to improve the confidence level and public acceptance regarding reactor safety, and such matters as legislative and budgetary requirements for the program.

Turning to the study's tentative conclusions, I think the following chart (Chart 2) can make clear my explanation. As the chart indicates, the selection-licensing-construction cycle for nuclear plants today requires 9-10 years, divided roughly as follows: 2 years for site and plant design selection, pre-application site reviews and preparation of the application; 2 years for construction permit reviews, including public hearings; and 5-6 years for construction, operating license review and possible hearings after the construction permit is issued, and operational testing. As you can see standardization of plant designs, including both nuclear and non-nuclear portions, can make possible a reduction of about 2 years in this cycle. About a year can be saved from the time required for AEC review of the construction permit application. In addition, as the industry begins to gain experience in duplicating major portions of plants, it should be possible to reduce the required construction time by a year. The saving will come largely from elimination of the trial and error sequences—the so-called "put it in—tear it out" syndrome—which characterizes the construction of many custom plants.

There is opportunity for cutting an additional two years from the early part of the nuclear lead-time cycle by coupling standardized plant designs with the use of sites reviewed and approved in advanced of their use. A bank of approved sites can be established once certain tools are available. These include siting criteria on such subjects as seismicity, population distribution, routine releases, and environmental characteristics. Use of a predesignated site should cut about in half the two years required for site selection. Should a utility elect to install a plant of preapproved standard design at a predesignated site, the only site-related question which would need to be addressed in considering a construction permit for a specific plant would be whether the standard plant's previously approved design characteristics fall within the assumptions used in evaluating the site.

No one should have the idea that all the time savings represented by this conceptual scheme are attainable in the immediate future. The savings expected from standardization will not be realized in full until entire plants, including both nuclear and non-nuclear portions, are standardized. This will not be achieved for some time.

In the siting area also the developments which can make this scheme a reality may be several years away. But the direction indicated by the chart seems realistic to me, and the goal represented is one which we hope to achieve, if not in the near term, at least in the intermediate term.

It is my hope that the AEC's study of the reactor licensing process will serve as a catalyst for additional viable approaches to the problem. In this connection, one of my fellow Commissioners, Will Kriegsman, has surfaced an approach which merits careful appraisal. Mr. Kriegsman's proposed formulation would split the current licensing system into two distinct and separate regulatory modes. Utilizing a modification of the currently available manufacturing license concept, reactor vendors would carry the burden of proof at the front end of the system to obtain a regulatory certified nuclear island portion of a final plant design. Utilities would only enter the picture at a later stage as they and their architect-engineers carried the burden of proof regarding balance of plant and site-related interfaces to obtain what amounts to the present operating license. In an alternative, an architect-engineer could join with a vendor at the certification review state to obtain a complete plant design approval. While this concept of a license to manufacture may eventually result in a reduction of 1 to 2 years in the length of the licensing process, this saving would appear not to be possible for another 3 to 4 years when final designs are available.

Although benefits and drawbacks can be cited in both Regulatory staff's and Mr. Kriegsman's proposals, both set the tone for the future. The AEC, the public and the industry simply cannot stay wedded to a licensing system which becomes more and more outmoded with each passing day given the projected orders of plants and the current severity of the energy crisis. We all must break out of our preconceived notions and meet the challenges with innovative thought and action.

Steps Toward Standardization

Significant progress has been made since the Commission's May 1972 policy statement endorsing standardization. As you know, the Commission believes that the continual changes in design of recent years, together with accompanying escalation in plant capacity has been a major cause of long lead times, requiring both industry and the AEC to go over each plant in detail in order to maintain a consistent high level of safety. As we looked ahead, the Commission came to the realization a few years ago that it could not effectively regulate the avalanche of nuclear orders forecast for future years, mounting to a predicted total of 1,000 operating plants by the year 2000, if each one was a custom plant. We also strongly doubted that the industry could design, construct and operate that number of plants on a one-of-a-kind basis. In March 1973, AEC announced three standardization options which we were prepared to implement in our regulatory process.

The first option is the reference system approach under which standardized designs intended for use in a number of future plants may be submitted for AEC regulatory review. Utilities purchasing plants incorporating the design can reference it and concern themselves in detail only with site-related and balance-of-plant matters.

All five major reactor manufacturers are responding under this option. We already have accepted for technical review the application by General Electric of its design known as GESSAR. An application from Combustion Engineering for its CESSAR design has been submitted for acceptance review, the procedure under which AEC examines applications for completeness prior to docketing them for technical review. An application is anticipated for three Arizona plants which will reference the GESSAR design. Westinghouse, Babcock & Wilcox, and Gulf General Atomic have indicated their intent to submit reference system applications. Two applications are anticipated from Stone & Webster: one, for a pressurized water reactor, is expected early next year; the other, for a boiling water reactor, later on.

As a matter of interest, the Commission is currently considering limiting the reference design submittals to very large portions of the plant, starting in FY 1977. Under this limitation, the minimum portion of the plant that would have to be included in the reference design option might be the reactor, containment, control room, auxiliary systems, radwaste systems, and emergency power. The objective here is that the full benefits of standardization really cannot be achieved unless large portions of the plant are standardized.

The second standardization option made available is the duplicate plant approach, under which the AEC agrees to conduct a single review when a utility or group of utilities plans to locate identical plants at more than one site. Each site must be specified at the time of the applicant's permit submissions. We have already received indications of several filings under this option:

- Commonwealth Edison Company has filed for its two Byron-Braidwood plants, to be placed at separate sites. This application has been docketed for technical review.
- The SNUPPS organization of five midwest utilities, having cleared Justice Department anti-trust scrutiny, is preparing to file an application covering six units at four different sites.
- Duke Power Company has signified its intention to purchase six identical plants from Combustion Engineering, and expects to file an application next spring.
- The Tennessee Valley Authority plans next summer to submit an application covering four GESSAR units on one site.
- Utilities in Wisconsin and upper Michigan are planning to submit an application covering two units.

As standardization progresses under the second option, the Commission will probably have to consider requiring some minimum number of plants to be included in applications, i.e., there should be sufficient commercial utilization of the design to warrant the expenditure of AEC regulatory review resources.

The third option in standardization involves issuing a license to manufacture where a number of complete facilities would be built at a central location and then moved to their operating sites. Early this month the AEC adopted new regulations governing the use of this approach. Under this option the purchasing utility must file separately for a construction permit and operating license. This option is currently being applied to the concept of floating nuclear plants placed in offshore locations. An application to manufacture eight such units has been received from the Offshore Power Systems, Inc., a joint venture of Westinghouse and Tenneco, and is now undergoing technical review. The Public Service Electric and Gas Company has purchased two units to be located off New Jersey and has taken an option on two additional units. The City of Jacksonville has signed a letter of intent to purchase two units, as has Middle South Utilities Company.

Although standardization is expected to have beneficial effects in reducing lead-times and conserving the technical manpower in industry and government, I would emphasize that one of AEC's principal motives in encouraging standardization is the enhanced safety this concept offers.

We expect this to occur because, with only a relatively few designs to be concerned with, greater concentration of staff effort will be possible, both in AEC and in industry. In addition, standardization will provide an opportunity to apply the lessons of experience with a given design in the design, construction, startup, operation and inspection of additional units, thereby saving valuable time.

As a matter of fact, within the next few years, we are considering requiring utility applicants to reference approved, final, standardized designs, unless good cause is shown why a custom design or a preliminary standardized design should be considered instead.

Siting Concepts

AEC's position and my personal position on the siting of nuclear power plants has undergone some recent change.

Several years ago there was strong emphasis on the desirability of regional siting. I recall well one instance which occurred while I was Chairman of the Maryland Public Service Commission. We had before us the application from the Baltimore Gas and Electric Company to place two plants at the Calvert Cliffs site on the Chesapeake Bay. We felt that some sort of regional compact for the Bay would be desirable since, regardless of what action we might take to protect the Bay on the Maryland side, there was still the possibility that Virginia could ring her side with plants, and of course vice versa. Accordingly, I met with Virginia and Maryland officials from the Governor on down but I was not able to get the regional compact idea off the ground.

Regional siting compacts are as good an idea now as they were then. But we must face reality. The experience we had with Chesapeake Bay seems to be the general experience on proposals of this kind. State governments do not seem to respond to the idea: the compacts are not forthcoming. I have had to conclude that regional siting is a frail reed on which to base a siting policy and that other approaches are required.

Moreover, other approaches are required urgently if acceptable sites are to be found for the numerous nuclear plants expected to be in operation in the coming years. Let me describe a siting proposal which appears to have real merit.

Designated Sites

The designated site approach seems to be a practical one. Its merit is in the decoupling of the approval of the site from approval of the plant. Such a site approval process would have to include consideration of all of the environmental aspects of the site that could affect plant safety (such as seismicity), all of the radiological impacts of the plant, and all of the environmental impacts of the plant on the site. Since the design of the plant may not be known at this stage, a typical operating envelope for the plant would have to be assumed, thus highlighting the need for developing good siting criteria. Where qualified, it appears reasonable if not desirable that the state could be involved in or be responsible for the nonradiological portion of the NEPA review. In this regard, the staff is currently developing legislative and non-legislative options to permit such governmental collaboration.

Immediate Actions

What I have said up to now related primarily to near-term and long-term policy objectives. In light of the seriousness of the energy crisis we face today, the tough question is increasingly asked as to what measures can be taken immediately and without legislation to increase nuclear's contribution. I should like to spend a few minutes on that subject. As a prelude to my remarks, it must be clearly understood that in my judgment the quality of the AEC's safety and environmental reviews cannot be sacrificed or prejudiced because of the presently anticipated severity of the energy shortage. With that as a pre-condition, three alternatives to the present system can be identified.

First, with regard to the 59 nuclear plants under construction, a great majority could be evaluated in ways which focus intensive attention on their construction schedules to identify government or industry actions which could accelerate the process. Utility management should consider taking a page from the AEC book and become involved in establishing and reviewing a PERT-type logic network to monitor plant construction progress. AEC has done this with its licensing schedules, and it's amazing how quickly problems can be identified and corrective actions taken under such a system. In that connection, I appreciate the cooperation of those industry leaders who I mentioned earlier met with Roy Ash, John Love, Dr. Ray, and me. That meeting can only have beneficial results as the administration's energy program evolves and construction delay problems are increasingly focused upon.

Secondly, while the project time for a reactor has significantly increased, the time required by the AEC to review construction permits has been steadily declining from an average of 35 months for cases docketed in 1970 to 18 months for cases docketed in 1973. Starting April 1, 1974, I expect the Regulatory staff to reduce the construction permit review time to 12 months. Additional attention must be given to the possibility of reducing this time even further.

Thirdly, the Commission amended its rules in March 1972 to bar site preparation work prior to the issuance of a construction permit and to restrict severely the granting of exemptions for this and for other site work. At the time it was an important and necessary step taken, among other reasons, to increase the credibility and effectiveness of the AEC's regulatory licensing process, particularly with regard to environmental matters. As you well know, it is the Commission's present policy to grant exemptions from these restrictions very sparingly. However, in the present energy climate where exemptions are and will necessarily have to be granted from provisions of the Clean Air Act and

other strict environmental measures, it would be appropriate for the Commission to consider the advisability of granting exemptions—where warranted in the public interest and compatible with applicable law—on a less restrictive basis than is now the case. I would emphasize that any exemptions permitted under the Commission's regulations are given with the clear understanding that the work conducted is at the applicant's risk; and that situation would continue to obtain notwithstanding any other changes in the Commission's exemption policy.

I personally would not be in favor of granting exemptions of any sort for first-of-a-kind demonstration plants. But with regard to the type of commercial reactors going on-line today, two possible alternatives for broadening the use of pre-construction permit exemptions come to mind. Under the first approach, staff could be geared up to complete its environmental impact review in 7 months rather than in the current 10-12 month period. Staff's final environmental statement would then serve as the basis for construction permit environmental hearings, and a subsequent positive finding by an Atomic Safety and Licensing Board could result in the immediate issuance of an exemption by the Director of Regulation. Alternatively, requests for exemptions could be submitted to a rigorous cost-benefit analysis of energy-environmental considerations, with the analysis specifically addressing the benefits from the standpoint of the construction schedule which would be derived if early site preparation and certain construction activities were permitted. Thereafter, an opportunity for public hearing on staff's mini-environmental review could be offered.

Obviously, I would personally much prefer to avoid the widespread use of pre-construction permit exemptions. While granting exemptions under appropriate safeguards seems reasonable for consideration given today's national energy picture, we must recognize that a price is paid. Here I am speaking of the risk of decreased credibility exemptions generate within a local community which often raises significant questions concerning the location of a nuclear plant on a particular site. It is hard to maintain credibility and counter charges that AEC's licensing process represents something other than objective decisionmaking when ground is being disturbed and even limited construction is underway before a construction permit is granted. Nevertheless, we simply cannot blind ourselves to our Nation's critical energy needs. So, as hard as it is for me to swallow, and given the fact a broader use of pre-construction permit exemptions could save at least from six months to a year in plant construction time depending on the alternative chosen, I will recommend consideration of such a course to my fellow Commissioners upon my return to Washington.

The Nuclear Controversy and the Commission's Response

Today I have for the most part addressed the mechanics of what I and to a large degree the Commission feel are the major policy objectives for the years ahead. There are, of course, differences of opinion as to the precise courses which the agency or the industry should pursue. But there is seemingly little difference with regard to the objectives. However, the primary objective for the future cannot be addressed in any mechanistic sense. This is the problem of achieving a high level of acceptability for an improving technology which has been and is being tested in the crucible of experience. And if we conclude that licensing and hearing delays through intervenor tactics are constraining the ability of nuclear power to make a more significant contribution to the national goal of energy self-sufficiency as embodied in project independence, it must be because a satisfactory level of public acceptability for the technology has not been achieved. While the overwhelming consensus of the scientific community supports the safety, environmental and technical feasibility and advantages of nuclear technology, no conscious or even subjective choice, positive or negative, has been made by many Americans. For example, a recent industry-sponsored survey indicates that over 25% of those surveyed had "no opinion" when it came to attitudes toward nuclear power plants. This is in the face of decisions by a significant portion of the utility industry to provide electricity generated by commercial nuclear power plants. Rather, there are all too many instances of public doubt and questioning of the wisdom of such decisions. And yet even in areas where controversy has been engendered in the context of individual licensing hearings, surveys have shown the level of acceptability for nuclear power has been significantly increased. The conclusion is obvious. Exposure to the facts concerning nuclear technology via public participation and the media generates a higher degree of acceptability. The technology can withstand the most searching inquiry in the most public forum and emerge with a public acceptability an order of magnitude higher than when the dispute began.

It is clear to me that the level of maturity in the nuclear industry requires that the Commission, in addition to other policy objectives currently being identified and pursued, should do some re-thinking both in the operational and regulatory organizations to eliminate where possible from the public debate over nuclear energy extraneous arguments which cloud and make impossible meaningful dialogue. Many of the policies and operational procedures of the AEC are in fact residual holdovers from earlier days and have their genesis in operational requirements mandated by the weapons program of the Commission. While those requirements still exist and will continue, the Commission must more aggressively address a bifurcated methodology of administration distinguishing its nuclear responsibilities in the civilian area from its responsibilities in the national security area.

The Commission, exercising its own initiative, has taken steps in the past several years in a calculated effort to open up to public scrutiny those of its activities dealing with peaceful uses of nuclear energy. Rightly or wrongly, however, a sense of the openness of the process has not come through to the public to the degree necessary to eliminate from the nuclear debate the charge of "secret decisionmaking."

As I am sure you are aware, the Commission is in the process of taking a number of significant and rather dramatic steps to address this problem. To begin with, the question of proprietary information—a needlessly vexatious matter in the licensing process—is being re-examined by the Commission, and a rulemaking proceeding on this subject will be announced in the next few days.

Further, steps are being taken which are designed to make more regulatory technical information routinely available to the public. Research and technical assistance documents will be made available in the Public Document Room at the time they are submitted to Regulatory staff. This will include reports received from AEC contractors and consultants, memoranda to the AEC operational organization concerning Regulatory staff's safety research needs and reports prepared by staff which are generic in nature. We also plan to encourage increased public participation in the rulemaking process by expanding use of advance notice to the public of proposed rulemaking and inviting advice and recommendations at an early stage before staff is prepared to issue the specifics of a proposed rule for public comment. Additionally, steps have already been taken to open meetings of the ACRS and other AEC advisory committees to public attendance, and further measures are under consideration to provide greater access by the public to ACRS documents.

In addition to the foregoing actions, we plan to make available to the public upon request early drafts of proposed regulations and safety guides normally exempt from disclosure under provisions of the Freedom of Information Act. The guidelines for such release are as follows: (1) once a regulation or safety guide has been published in proposed or effective form, we would make available prior drafts of the regulation or guide prepared by the Regulatory staff (or personnel of the Office of the General Counsel advising the Regulatory staff) which have been transmitted outside the regulatory organization following establishment of a regulatory position on the particular subject; and (2) irrespective of whether the regulation or safety guide has been published, we would follow the same course just outlined on drafts which have been transmitted outside the regulatory organization following establishment of a regulatory position on the particular subject.

All the foregoing measures have been taken not without travail, and some have been taken at the urging of concerned citizen groups. But regardless of who generated the measures, I personally believe they are all steps in the right direction and more needs to be done.

An unfortunate and regressive aspect of the controversy over nuclear power in the past decade has been the fact that all too often extraneous, irrelevant and in some cases just plain phony issues have been injected into the public arena as somehow having some sort of mysterious but direct relationship to the adequacy of nuclear technology—issues such as Commission procedures; the stifling of dissent within the Commission's technical body; the non-disclosure of documents which somehow, if exposed to public view, would allegedly "do in" the technology; and the allegation that the Commissioners themselves are somehow engaged in league with the industry in some sort of perverse game plan to foist nuclear power on an unsuspecting public. These charges often are made in a manner designed to mislead the public and to exploit the regrettable fact that nuclear energy was developed in a wartime atmosphere and that its first use was for destructive purposes. For more than a quarter of a century the public has been prey to those who would dramatize and emotionalize this legacy from the past. It frankly is time that this industry, this Commission and this country lay this kind of lazy mentality to rest and get off the back of civilian nuclear power the "bum rap" that the nuclear technology has taken in recent years. It is high time the unreasoning critics of nuclear technology be informed that they are going to be held to a higher standard of accountability and that the nuclear dialogue requires a more informed debate based on precise facts, not overstated generalizations.

Epilogue

It is clear to me, as it should be to you, that with regard to nuclear energy and the present and projected fuels shortage, the gauntlet has been thrown down. I have today endeavored to describe actions the Commission is taking to meet its public interest responsibilities. These are being accomplished under the rubric of foresight and with the watchword of openness. And, if some of my comments have made you feel uneasy in your seats, all the better. You are the leaders of this industry and your industry does not lack the maturity for aggressive responsiveness to the country's needs. I challenge you as the President challenged the Nation and AEC in his last energy message. Collectively you will have much to say about the future viability of this Nation. I urge you not to drop the ball. If some of you think that the only response to the energy crisis should be the embracing of the lessening of environmental restrictions occasioned by the fuel shortage, you have completely missed the point. That kind of simplistic thinking is for the Dark Ages. And that is where this country might very well find itself if all of us are not constructively responsive.

CHART 1

CAUSES OF SCHEDULE DELAYS IN 28 NUCLEAR PLANTS SCHEDULED FOR 1973 OPERATION

Cause	Number of Plants Affected	Plant/ Months Of Delay
Poor Productivity of Labor	16	84
Late Delivery of Major Equipment	9	68
Change in Regulatory Requirements	8	23
Equipment Component Failure	6	15
Strikes of Construction Labor	5	18
Shortage of Construction Labor	5	18
Legal Challenges	4	9
Strike of Factory Labor	4	5
Re-scheduling of Associated Facilities	1	12
Weather	1	9

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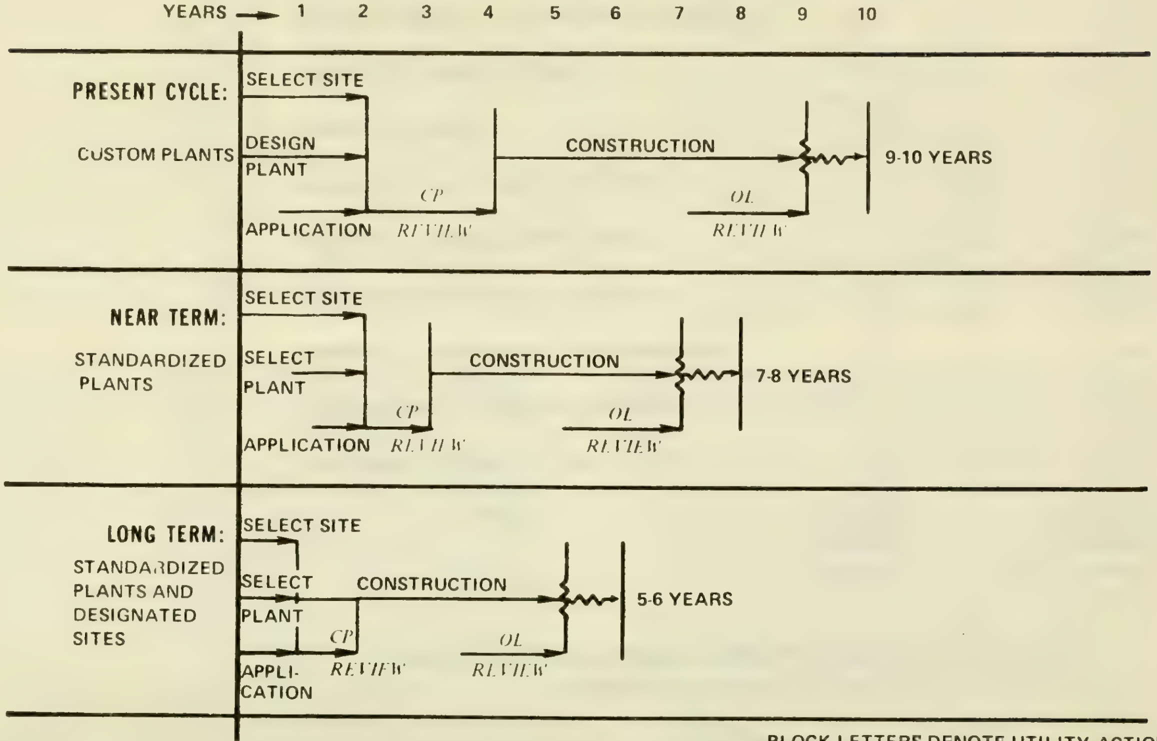
CHART 2

REDUCING NUCLEAR POWER PLANT LEAD TIME



BLOCK LETTERS DENOTE UTILITY ACTION

ITALIC LETTERS DENOTE AEC ACTION

Position Paper—A Strategy for Energy Research and Development

(By *Alvin M. Weinberg and Calvin C. Burwell*, September–October 1973.)

FOREWORD

The paper, "A Strategy for Energy Research and Development", was written during September and October 1973 before the current situation in the Middle East converted a very serious (and foreseeable) energy problem into a true crisis. Our main purpose in writing the paper was to illustrate one approach toward relating energy R&D strategy and energy policy - i.e., to show how the R&D strategy must flow from and be consistent with the overall policy. However, events have caught up with us; and what seemed like a fairly reasonable energy policy in September and October 1973 seems somehow inadequate in December 1973. Nevertheless, we believe the paper may present enough insights into the connection between energy policy and energy R&D policy to make it worth placing in the record.

There is one point of great significance which the events of the past few weeks have reinforced, and we take the liberty of quoting the following excerpt from the paper: "It would be a grave error to represent the large new energy R&D initiative as a means of alleviating short-range energy shortages. In point of fact, most of the money that is now contemplated for the R&D program is aimed at matters that can make little difference during the next 10 years. To lead the public to believe that R&D will make a great difference in a short time could backfire seriously." A program that can achieve "self-sufficiency by 1980" would be very different from the program discussed in this paper. Whether indeed "self-sufficiency by 1980" can be reached by any method - fiscal policy, regulation, or a crash Manhattan-type production program - we are not prepared

to discuss; yet, in view of the current energy crisis, this may be the most important issue of all. We hope that this matter will be taken up in a most serious manner in the coming months.

Alvin M. Weinberg

Alvin M. Weinberg

Calvin C Burwell

Calvin C. Burwell

December 3, 1973

A STRATEGY FOR ENERGY RESEARCH AND DEVELOPMENT

Alvin M. Weinberg and Calvin C. Burwell

I. NATIONAL GOALS AND GENERAL OBSERVATIONS

Few subjects have been discussed and analyzed more extensively in the United States in recent years than has the energy situation. Most of the studies and reports by now say rather the same things: our demand for energy is outrunning our supply; the increase in demand shows little sign of abating; we must therefore take steps, both technical and administrative, to reduce demand and to increase supply. These measures must be consistent with an acceptable environment, continued economic health, adequate national security, and tranquil foreign relations. That many of the reports sound much alike probably means that a national consensus with respect to energy is beginning to develop. That the desired goals are often in conflict - for example, clean environment and low cost, or acceptable cost and minimal risk, or diminished demand and stable economy - illustrates the inherent difficulty in formulating a rational energy policy and the R&D strategies that might be devised to help implement such a policy.

This paper is a rather personal attempt (we make no claim to the completeness and comprehensiveness that is to be found in many of the available Government reports) to restate and articulate the goals of our energy policy and to formulate the R&D strategies that might help achieve these goals. The goals themselves are implicit in the several white papers on energy issued by President Nixon (June 4, 1971, April 18 and June 29, 1973), particularly the most recent one which asks the Chairman of the Atomic Energy Commission to recommend an "integrated [energy] research and development program for the

Nation". Our formulation of the goals is also influenced by various proposals that have come from Congress, and has been particularly influenced by Carroll Wilson.[1]

Once the goals of our energy policy have been stated, it becomes possible to estimate what energy R&D probably can do to achieve these goals; perhaps equally important, it becomes possible to estimate what energy R&D probably cannot do. We accept the idea that science and its technologies can help resolve both the short-term energy crisis - e.g., put more gas into our service stations - and the long-term energy dilemma - i.e., we cannot forever increase our pressure on finite energy resources. But it would be a fallacy to assume that the energy problem with its immense social, economic, technical, and international ramifications can admit of any simple technological fix or array of fixes. Intelligent policy formulated on the basis of serious, scholarly analysis can do more than technology, at least in the short run.

It will be our purpose to estimate how much we can expect and at what cost from the various energy technologies, both in the short run and in the long run. In making these estimates we shall naturally be establishing priorities among the different technologies; and we thus shall be establishing a framework for the specific budget allocations for energy R&D that are called for in the President's June 29 message. Since most of the technologies we shall discuss have already had an extensive review by previous groups, most notably the Office of Science and Technology (OST) Energy Advisory Panel,[2]

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[1] "A Plan for Energy Independence", FOREIGN AFFAIRS 51, 657-675 (July 1973).

[2] "A Summary of An Assessment of New Options in Energy Research and Development", prepared for the National Science Foundation Energy Task Force by Associated Universities, Inc., Upton, New York (June 7, 1973).

much of what we say about specific technologies will be found in other studies and has been correspondingly influenced by those studies.

Energy R&D is presently conducted on a very large scale by private industry. In this respect, the Government's embarking on an R&D program of $10 billion in five years is somewhat unique. The three other governmental programs of comparable magnitude and intensity - space, atomic energy, and to some degree military R&D - were launched by the Government where there was almost no involvement or expertise in truly competitive private industry. To put a man on the moon or to develop submarine reactors, the Government had to create new research instrumentalities, either within Government or by contract. But with an already existing private energy industry that conducts its own R&D, the role of the Government must be different. The intricate relation between Government and private industry, as well as the appropriate structure of the Government R&D establishment in this unique situation, must therefore be an important part of this analysis. We shall discuss a few of these institutional questions in the fourth part of this paper.

II. THE GOALS OF ENERGY R&D POLICY

We distinguish between short-range and long-range goals of energy R&D policy. The short range we take as the period during which major new research findings and developments (as contrasted with applications of existing technologies) can hardly make an impact on either our energy supply or our demand; this we place, admittedly somewhat arbitrarily, as the time from now until 1985, or 10 years from the beginning of the President's proposed five-year plan. The long range we take to be the period beyond 1985. Our

entire formulation of the energy goals and the corresponding research strategies will be cast separately in terms of the short range and the long range.

The Short-Range Goal: Foreign Oil Importation

We now use about 72 mQ[3] of energy per year. At the present rate of increase in energy use (4.5 percent annually),[4] this will grow to about 125 mQ/yr in 1985; should we succeed in reducing the rate of increase to three percent per year, we shall use about 100 mQ annually in 1985. Presently, 44 percent of our energy comes from oil - i.e., 32 mQ/yr; of this, 12 mQ/yr is imported. With out-of-pocket costs of imported oil averaging 40¢/MBtu, we can expect a $5 billion foreign exchange deficit for oil in 1973.

By 1985, various studies[5] suggest that we shall use over 51 mQ/yr of oil. If domestic oil production in 1985 is 21 mQ/yr as predicted, oil imports will have to rise to perhaps 30 mQ/yr.[6] At that time, the out-of-pocket cost of oil will increase to perhaps 80¢/MBtu, and our foreign exchange deficit for oil will amount to some $25 billion/yr (1985 dollars).

It is possible to dispute the precise figures that are used in this projection; one can hardly deny, though, that foreign oil will play an

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[3] 1 Q = 10^{18} Btu; 1 milli-Q (mQ) = 10^{15} Btu. 1 mQ/yr corresponds to 0.5 x 10^6 barrels of oil per day.

[4] Some authors put this rate of increase at 4.2 percent, depending upon years used to calculate the average.

[5] These are elaborated under The Role of Scenarios, page 8.

[6] Of this, about 23 mQ/yr is expected to come from the Middle East and Africa.

increasingly important role in our balance of trade. Beyond this, there are many reasons related to our position as a force in international affairs that favor our maintaining a high degree of self-sufficiency in oil. These include not only our political stance in the Middle East, but also the advantages of not appearing, to the rest of the world, to be using a disproportionate share of the world's energy resources. It is no wonder that the President, in his energy message of April 18, 1973, speaks of "reducing our long-term reliance on imports" of oil.

We shall therefore propose as our primary goal for 1985 the reduction to an acceptable level of our dependence on foreign oil. We are reluctant to specify precisely in barrels per day what this reduction should be since our overall demand for energy in 1985 is itself uncertain. Two criteria, however, suggest themselves: first, that our import of foreign oil by 1985 be so low that loss of this increment would not cause major social or economic dislocation; and second, that our participation in the world oil market be sufficiently small as to minimize competition and therefore possible conflict between the United States and other nations for the world's limited supplies of oil. Though we hesitate to translate these requirements into precise figures, we suggest keeping our foreign imports to less than 25, and hopefully as low as 15, percent of our 1985 total oil demand. If our total oil demand rises to 51 mQ/yr, this would mean holding our foreign imports of oil to less than 13 mQ/yr and hopefully as low as 8 mQ/yr. The remaining shortfall would have to be made up by increased domestic production of oil, by substitution of other energy sources, and by reduction of our demand.

We would suggest, though tentatively, a subsidiary goal that may be desirable on rather general grounds: that the United States seek to export, largely in the form of coal and enriched uranium, at least as much energy as it imports. The rationale for this goal is twofold. First, the U. S. would thereby improve its balance of trade; and second, the caricature of the U. S. as the consumer of a disproportionate share of the world's energy resources would to some degree be mitigated. In the case of enriched uranium, some of the export could in principle be achieved without drawing on domestic reserves: toll enrichment would add value to a raw material mined outside the U. S.

The Long-Range Goal: National Capability for Energy Self-Sufficiency

In a trivial sense, we now have a national capability for self-sufficiency, but at a price that most would consider unacceptable. For example, we can now liquefy coal (by Fisher-Tropsch) at $2.60/MBtu; or we can impose draconic regulatory measures that would possibly halve the energy required for individual transport. However, such measures are hardly realistic options and cannot be represented as a response to a desire for self-sufficiency.

Moreover, in viewing the long-term picture, we encounter many uncertainties in our projections for energy use; in our measurement of environmental, economic, social, and political (particularly international) costs; in the degree to which the marketplace itself will diminish demand.

Our demand for energy by about 2050 will be a good deal higher than it now is, whereas the world's oil supply is unlikely to have increased correspondingly. On this account alone it would be unrealistic to claim

15 to 25 percent of our domestic oil demand, say as much as 250 mQ/yr, from the world oil supplies by 2050. Thus we would project as a national goal beyond 1985 a gradual reduction of the fraction of our imported oil supply, perhaps holding the absolute amount to no more than we import in 1985. This strategy would gradually tend to make us self-sufficient in energy.

If one views the long term from a larger perspective, such sharp focus on the oil supply alone is unduly restrictive. In the very long term (some time after 2100), we shall no longer have fossil fuels. In the interim, coal will take over many of the functions now assigned to oil, in petrochemical industry as well as in production of energy. Thus as a broad, national long-range goal, we must prepare for a very extensive transformation of our energy system from one based primarily on fossil fuels to one based on sources that are far larger: the sun, fission, fusion, and possibly geothermal. Our ultimate objective must be to reduce gradually our dependence on fossil fuels, particularly oil; this transition will first be manifested in less dependence on oil and greater dependence on coal and uranium.

A related aspect of our longer range goals is the relative importance of electricity in our future energy system. Again, in the very long range where we must depend on the sun, nuclear energy, and geothermal energy, we may visualize an energy system consisting of primary electrical generating plants, and secondary synthetic fuels - e.g., hydrogen - derived from the primary electricity. This view of course discounts the substantial contribution the sun can make directly to domestic and possibly industrial heat without conversion to electricity; but, in the main, the society will be all-electric, with secondary energy systems derived from electricity or at least from the primary heat sources that generate our electricity.

But this all-electric society, though very attractive, is hardly relevant for the time between now and well into the next century. During that period we shall have to depend on all of our energy sources, both those that are most conveniently converted to electricity (nuclear) and those that can be used well without such conversion (oil and gas, either natural or synthetic, and coal). Our energy system will remain multi-modal for many years; the transition to the all-electric society must be achieved by degrees.

The Role of Scenarios

We are trying to project our needs for energy research and development for a future that is 10 years away for the short term, and up to 30 or more years hence for the long term. Granted that accurate projection of this sort is impossible in principle, it is still useful to devise scenarios as to possible futures. Such scenarios have been devised by various energy systems analysis groups, in particular those at Brookhaven National Laboratory and at Lawrence Livermore Laboratory. The BNL group has constructed a Reference Energy System (RES)[7] for the U. S. which disaggregates energy demand into its various sectors - industrial, residential and commercial, transport - and tries to construct future demand by analyzing the separate demands of each sector. The RES also disaggregates the supply so that, from it, one can predict what the effect on one means of energy supply would be if a change occurred in another means. In formulating our R&D strategies, we shall perforce have to rely on scenarios. In the main, we shall use the

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[7] "Reference Energy Systems and Resource Data for Use in the Assessment of Energy Technologies", Submitted to the Office of Science and Technology by Associated Universities, Inc., Upton, New York (April 1972).

Livermore scenario as modified by the JCAE report concerned with evaluating the energy crisis;[8] and, to a lesser extent, the projections of the Institute of Gas Technology (IGT). However, we must repeat our original caution: that projections as to the future are inherently uncertain. Judgments based on any scenario must be tempered by common sense.

The Role of Conservation

It is apparent that, regardless of the technological fixes we can invent for producing more energy, both for the short run and for the long run, we shall need to reduce the growth rate of energy demand. Since 1960 we have used more than four percent more energy each year than during the previous year. Projected (at 4.5 percent/yr) to the year 2000 this would lead to a demand of about 240 mQ/yr; by 2050 the demand would reach the preposterous level of about 2200 mQ/yr!

The demand for energy will eventually saturate. We do not, however, understand the forces that reduce energy demand. Some studies show that the market itself can help limit demand - that, for example, a one percent increase in cost of electricity relative to the cost of energy in some other form will reduce the demand for electricity by about one percent. But such assessments are evidently uncertain in the extreme; and we would suggest that, as a matter of policy, it would be imprudent to base our plans for achieving a national capability for energy self-sufficiency on the feedback of the marketplace alone. Moreover, if the primary aim is to replace scarce

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[8] Staff of JCAE, "Certain Background Information for Consideration when Evaluating the 'National Energy Dilemma'", U. S. Government Printing Office (92-923), Washington (May 4, 1973).

oil and gas with abundant coal and uranium, then raising the cost of electricity relative to other energy forms could be counterproductive. Space heating which now makes heavy demands on our oil and gas is more likely to be done electrically if we lower rather than raise the cost of electricity. In summary, a lower overall demand for energy can be expected if the price of all forms of energy increases relative to the price of other goods. The demand for electricity will increase if its cost increases less rapidly than the cost of oil and gas.

The importance of conservation in bringing our energy demand into better balance with our energy supply has been studied extensively and reported by the Office of Emergency Preparedness.[9] The OEP report suggests that conservation measures might reduce estimated energy demand by 1985 by as much as 15 mQ/yr. The most important of these measures are: (1) improve insulation in homes; (2) adopt more efficient air-conditioning systems; (3) shift to less energy-intensive transportation modalities; (4) use energy more efficiently in industry.

Some of the conservation measures require technology development - for example, higher efficiency topping cycles. The most important impacts, however, come not through R&D but rather through more extensive use of technologies that are already available. One gets from the Office of Emergency Preparedness report the strong impression that energy conservation is far more a matter of getting people to use energy more sparingly than it is inventing specific new technologies. The kind of R&D that might make the most impact on conservation is therefore not traditional hardware development, but rather

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[9] A Staff Study, "The Potential for Energy Conservation", U. S. Government Printing Office (4102-00009), Washington (October 1972).

policy analysis backed by sophisticated engineering estimates of various alternative courses.

Technology of course can help; for example, the efficiencies of central station power plants could be raised to 50 percent if one of the topping cycles now under development succeeds. Or the gas mileage of automobiles might be increased if we adopt or develop more efficient engines, or if we turn to smaller or better streamlined cars.

These particular approaches to reducing energy demand make rather different claims on the individual consumer and, for that matter, on the regulatory agencies of the Government. To increase gas mileage by reducing the size of the automobile requires cooperation between the car-buying public and the car manufacturer - the latter to manufacture the smaller car, the former to be educated to buy a smaller car. In addition, Government regulation limiting, say, the power of each car may be required. To increase the <u>efficiency</u> of a car, however, makes relatively small demand on the individual (unless this increase raises the initial cost substantially). Similarly, to increase central station power plant efficiency requires only a technological development; it does not require change in the tastes of the general public, nor Government regulation. And indeed, some technological measures to conserve energy make heavier demands on the regulatory agencies and on the public as a whole than do others. In charting an R&D policy one is generally inclined to stress those developments that minimize the social component required to achieve a desired degree of conservation - that is, to use a technological fix. Unfortunately, such socially neutral technologies may not conserve as much energy as do technologies that make heavier demands on the individual - e.g., smaller cars affect individual habits much more

than does increasing power plant efficiency to 50 percent, but smaller cars will have a bigger impact on our oil imports than does high efficiency in our power plants.

What technology can do to conserve energy is limited, particularly where the use of less energy in some way affects the life style or even the customary habits of many people. It seems inescapable that to achieve an average 3 percent growth rate rather than a 4+ percent growth rate between now and 1985 will require very extensive social action. Science and its technologies will be necessary, but they will by no means be sufficient.

The Role of Environmental Constraints

A good part of our energy crisis stems from our heightened environmental sensitivities. Because we are now required to reduce the emission of SO_2 from a central power station to 1.2 pounds of SO_2/MBtu, stations that burned eastern coal with a sulfur content ranging up to 5 percent have converted to high-grade oil with a sulfur content of less than .3 percent.[10] Because the AEC has reduced the allowable burden of radioactive exposure to 5 mrem/yr/person, light-water reactors must have additional equipment for cleaning effluents; this, together with the greatly heightened public concern over radioactive insult, has contributed to delays in installation of light-water reactors and has increased their cost. Because of concern over waste heat, there is a trend toward using cooling towers which add 5-10 percent to the energy required by a power plant.

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[10] "Material Needs and the Environment Today and Tomorrow", Final Report of the Commission on Materials Policy, pp. 5-12, U. S. Government Printing Office (5203-00005), Washington (June 1973). As a point of interest, a 1.2 pound SO_2/MBtu standard allows use of coal containing about 0.8 percent sulfur, or oil containing about 1.2 percent sulfur.

The environmental impact on our energy crisis depends almost directly on our standards of environmental purity. But here we enter a difficult, often vague, area that even goes beyond what our science is capable of. What is the scientific foundation for the EPA standards on SO_2 emission? And what impact would relaxation of standards have on our capacity to meet the national goals, both in the short run and in the long run? In implementing the previously stated national goals, we may have to clarify and rationalize our environmental standards.

III. THE ROLE OF RESEARCH AND DEVELOPMENT IN MEETING OUR NATIONAL GOALS

How much can we really expect from science and its technologies in helping to achieve both our short-range and long-range goals? In the short range our goals are rather definite, but the R&D done between now and 1985 is hardly going to make a great difference by that time. During this period we shall have to depend on available or nearly available technologies; more significantly, in the short range legal and political intervention, guided by intelligent policy analysis, will be more important than hardware R&D. In the long range, where R&D has time to make a difference, the goals are a good deal more diffuse and uncertain. The R&D aimed at the long run must therefore be correspondingly broad and open-ended.

This is only to say that energy R&D is a far more complex proposition than was R&D for the moon shot: not only did the moon shot operate outside the marketplace, and was there but a single customer, but more importantly the goal was precise and, as it turned out, there was enough time to achieve that goal.

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A better, though still over-simplified, analogy to the problem of formulating a sensible R&D program for energy is to be found in the history of nuclear power development. The first goal of nuclear power reactor development was submarine propulsion: this was a precise and definite national goal. The route to its achievement was fairly clear, and the Nautilus prototype, built in 1953, has been the basis for most submarine reactors. On the other hand, the goal of competitive central station power was much more elusive and difficult to define. Conventional power costs presented a moving target; it was all but impossible in 1946 to determine what cost nuclear power would have to achieve in 1966 if it were to be competitive. No less than 10 different approaches were tried in various parts of the world; and, though the light-water reactor seems to have emerged as the standard reactor type, it is still unclear whether some other system (HTGR or CANDU) may not eventually prove more economical than the light-water reactor. In this respect, our long-range energy R&D policy is faced with much the same kind of uncertainty as was faced by the civilian reactor program when it was started. Gambles will have to be taken; and we must expect some of the gambles to be successful, some to be unsuccessful.

It seems reasonable, then, to set forth several general principles regarding our overall energy R&D strategy.

1. We must distinguish between R&D that can make a difference by 1985, and R&D that cannot possibly affect things until a later date. One of the first steps in formulating an R&D policy is to decide, among the catalogue of R&D proposals, which can make a difference in the short run, which in the long run.

2. The R&D that can make a difference by 1985 would be based largely on existing technologies. This R&D program we designate the short-range

program (SRP). It must be sharply focused, rather like the Nautilus project.

3. The R&D programs that, even if successful, cannot affect our energy situation until after 1985 would constitute the long-range program (LRP). The long-range program must be carried out on a much broader front and with much more flexibility than the short-range program. It must include speculative, as well as more certain, possibilities. In this respect, the long-range program would resemble the early Civilian Nuclear Power Program in its general approach and pace.

4. Every technical approach to energy R&D will be constrained by economic, environmental, and social impacts. Thus, in comparing two R&D approaches to achieving the same goal, one must consider all three impacts: reduced to absurdity, one seeks the cheapest, cleanest source of energy that causes the least social and economic dislocation; or the cheapest, cleanest way of reducing energy <u>demand</u> that has the least impact on the Nation's economic health.

5. In particular, we stress the point made earlier: in assessing competing technologies that seek to achieve the same goal, preference should be given to the one that makes the least social demand on the individual energy consumer.

6. Since environmental standards play so great a role in determining what technologies are acceptable, the program must aim at rationalizing and clarifying these standards. In addition, the program should include assessments of the biological damage caused by environmental insult imposed by pollutants from energy systems and, if possible, research on reducing the severity of this biological damage - e.g., cures for disease induced by pollutants from energy sources.

7. Technological approaches alone will be insufficient, especially in the all-important matter of reducing energy demand. Insofar as systems analysis, economics, and other social studies can clarify our understanding of the growth in energy demand and suggest policies that will reduce demand, such studies ought to be encouraged. Studies of this sort are far less expensive than are technological developments. Yet their results can have profound effect on our energy policy - much more effect, especially in the short run, than can any technology.

8. The energy system is too complex for any individual, or even group of individuals, to keep abreast of all its facets and relevant data. It will be important therefore to establish an energy information system which would provide analyzed data for the use of researchers, research administrators, and formulators of energy policy.

A. THE SHORT-RANGE PROGRAM

We restate the short-term aim: To reduce our foreign oil imports to between 15 and 25 percent of our estimated total domestic requirement by 1985 - i.e., to keep our oil imports to between 8 and 13 mQ/yr, preferably the lower figure.[11] This aim is to be achieved without compromising our environmental standards or inducing severe economic dislocation.

What can make a real dent in our oil imports by 1985? Unfortunately, our need is for oil and gas; our abundant resources and our technologies are uranium and coal. The overall strategy in the short term must substitute the available resources and technologies for the unavailable ones.

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[11]We would suggest keeping our gas imports to between 15 and 25 percent of our total domestic requirement in 1985 also. However, gas, being more widely distributed than oil, poses fewer political problems.

Our short-term technological strategies for reducing our dependence on foreign oil and gas can be divided into four categories.

1. Reduce use of oil and gas for production of electricity
   a. Burn coal cleanly in central power stations
   b. Expand nuclear power based on current technologies
   c. Expand geothermal
2. Substitute electricity (or heat) generated without oil or gas for end-uses that now use oil and gas
   a. Space heating and cooling; water heating
   b. Mass transport
   c. Industrial heat and electricity
3. Produce more domestic oil and gas
   a. Synthetic gas and oil from coal
   b. Increase domestic production, including oil from shale and tar sands
4. Conserve energy

In examining the impact that each of these strategies can have on reaching our short-term objective, it is first necessary to review how our oil and gas are now used.

Table I shows the way in which gas and oil were used in 1970, and how they are expected to be used in 1985.

A glance at the table shows that the transportation sector is by far the largest user of oil (though not by so large a margin is it the largest user of oil and gas together), with the industrial and residential and commercial sectors also being quite important. All other things being equal, one would therefore place one's short-term priorities on technologies that would most likely affect the transportation sector. Unfortunately, this

TABLE I

Use of Gas and Oil in 1970 and Projection for 1985*

	1970 - mQ/yr			1985 - mQ/yr		
	Oil	Gas	Oil & Gas	Oil	Gas	Oil & Gas
Electrical Generation	2	3.8	5.8	3	3.4	6.4
Residential & Commercial	5	7	12	5	6	11
Industrial	3.2	9.2	12.4	8	9	17
Non-energy	3	0.6	3.6	7.6	---	7.6
Transportation	14.8	0.6	15.4	27.8	0.6	28.4
Totals	28	21	49	51	19	70

*Joint Committee on Atomic Energy report, "Certain Background Information for Consideration when Evaluating the 'National Energy Dilemma'".

sector is peculiarly subject to the vagaries of individual decision and preferences: small cars would almost surely save oil (unless their numbers increase in proportion), but what R&D per se can do to convert the United States from a large-car society to a small-car society is far from clear. On the other hand, the sector where individual decision is much less involved, and where technology can obviously make a short-term difference - electrical generation - uses relatively little oil and gas: 5.8 mQ/yr. An intermediate sector is the industrial one: here there are many medium-sized users of oil and gas, but their aggregate demand, 12.4 mQ/yr, is very significant. If a real impact could be made on the industrial sector, the pressure on the transport sector would be relieved greatly.

We shall now examine each of the short-term options.

1. Directly substitute available resources for oil and gas

   a. Guarantee and expand our coal option: burn coal cleanly in central power stations

An obvious quick fix is to burn more coal in central power plants. Insofar as mining and burning coal imposes serious environmental impact, our overall strategy can be described as guaranteeing the expansion of our coal option against compromise by environmental concerns.

Actually the direct impact on oil imports of using coal rather than oil in central power stations is rather disappointing.[12] Complete conversion of oil- and gas-fueled central power plants to coal (which is admittedly very optimistic) would, by 1985, reduce oil and gas imports by about 6 mQ/yr, of a projected 36 mQ/yr. The additional coal required to replace this much oil and gas in central generating plants would amount to about 230 million tons per year. The saving of 6 mQ/yr is a useful increment, but it is not in itself decisive. However, these figures may underestimate the importance of clean power from coal since there is a trend to convert from coal to low-sulfur oil simply to meet environmental standards; this trend would be counteracted if we could continue to burn high-sulfur coal. Moreover, in these estimates we have neglected the not unsubstantial use of electricity by industry in on-site stations.

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[12] In 1970 central station power plants burned 2 mQ/yr of oil, about 7 percent of all the oil we use in the United States, but 28 percent of the oil we import. This could be saved if all these power plants were converted to coal-firing or replaced by coal plants, however impractical. If the JCAE scenario were to hold, by 1985 3 mQ/yr of oil would be used for central station power; this, however, would represent only 10 percent of the projected import of oil.

The natural gas used in central power stations in 1970 amounted to 3.8 mQ/yr, compared to 1 mQ/yr imported. By 1985 this figure is estimated to be 3.4 mQ/yr, but the imports will have increased to 6 mQ/yr.

Four technologies may enable us to burn coal cleanly: tall stacks, stack-gas cleanup, advanced combustion, and low-Btu gas from coal.[13] Of these, the first two are rather immediate possibilities, and as such they are part of the SRP; the last two are intermediate possibilities which may or may not have short-term impact.

(1) Tall stacks - the importance of emission standards

To build a 1000- or 1500-foot stack requires no R&D.[14] What is not really known is whether the tall stack by itself reduces ambient SO_2 or sulfate concentrations to levels that are environmentally acceptable. It is not so much that the fallout from a tall stack plume cannot be predicted as it is that the standards themselves are difficult to establish. Present EPA standards set a chronic exposure of 80 $\mu g/M^3$ of SO_2 or a single 24-hour dose of 365 $\mu g/M^3$ of SO_2 as an acceptable upper limit. The EPA standard may be compared with the value recommended by WHO:[15] annual mean exposure less than 60 $\mu g/M^3$, 98 percent of observations less than 200 $\mu g/M^3$. There is evidence of adverse effect at 300 $\mu g/M^3$ in a single exposure, at 100 $\mu g/M^3$ in chronic exposure, if particulates are associated with the SO_2. To one accustomed to radiation standards where the ratio between an acceptable level and the level at which deleterious effects are found is perhaps 100, the

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[13]We mention in passing solvent refined coal and washed coal. However, we are inclined to consider the first as a variant of coal hydrogenation, and not as a short-term option, and the second (washed coal) as not producing a sufficiently clean product.

[14]The highest stack now in use towers 1200 feet.

[15]World Health Organization Technical Report #506, "Air Quality Criteria and Guides for Urban Air Pollutants"

small difference between acceptable levels of SO_2 and manifestly deleterious levels is very surprising.

Professor John R. Goldsmith[16] asserts that tall stacks are an adequate solution to the sulfur dioxide problem since this chemical is deleterious to human health only if soot is also present; and the tall stack gets rid of the soot.[17] This is reassuring testimony from an expert. Nevertheless, the issue is probably not as clear as the foregoing statement implies. In any event, a central need is to learn more about the effect on health of SO_2 and its chemical daughters; in particular, we should clarify why there seems to be a double standard of safety in dealing with SO_2 as contrasted with radioactive insult.

(2) Stack-gas cleanup (SGC)

The importance of stack-gas cleanup was recognized by the President in his June 4, 1971, Energy Message where he specifically directed EPA to conduct or sponsor additional research on SGC. At present the Government spends about $5 million/yr in demonstrations and research on SGC. Industry spends possibly 10 times as much on such demonstrations. No fewer than 17 different schemes have been brought to various stages of development; but no system has yet been demonstrated to work satisfactorily on a full-scale (500-MwE) power plant.

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[16] Bureau of Occupational Health and Environmental Epidemiology, California State Department of Public Health, Berkeley, California.

[17] "Based on present technology and information, power generation from fossil fuels can be carried out without any appreciable health hazard in the U. S. Any representation to the contrary is misleading." From Health Hazards for Power Plant Emissions, Presented at the American Medical Association's Congress on Environmental Health, Chicago, April 29-30, 1973.

Successful stack-gas cleanup has the advantage of being applicable to existing power plants: it would make abundant eastern high-sulfur coal an acceptable fuel. At the Cornell Workshop on Energy and the Environment in February 1972 SGC was considered to be a very difficult development that still faced serious technical and economic obstacles.[18] Recent estimates suggest that SGC might add as much as $70/kw to the capital cost of a power plant; this corresponds to adding about 15¢/MBtu or $3.75/ton to the cost of coal burned in the plant; the cost of operation and waste disposal almost doubles this increment. Nevertheless, of the immediate technologies (aside from tall stacks) that are likely to make clean energy from coal, SGC seems to be the most versatile. It is applicable to existing power plants, and it probably can make an important contribution by 1985. One cannot fault the original assessment of SGC as the most direct way to use high-sulfur coal, and we would concur in giving it the highest priority.

(3) Advanced combustion technologies such as fluidized beds in which the SO_2 is captured on mineral particles used to fluidize the coal can hardly be described as a quick fix; it cannot be added onto the existing power plants, nor is it clear that it can be developed in time to make a difference by 1985. We would assign this interesting possibility a lower priority in our SRP, especially since it is unneeded if SGC is successful.

(4) Low-Btu gas and topping cycles

Here again is a very attractive possibility: converting coal to clean low-Btu gas in situ and using it in a combined high-efficiency

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[18] "Summary Report of the Cornell Workshop on Energy and the Environment", sponsored by the National Science Foundation and Committee on Interior and Insular Affairs, U. S. Government Printing Office (76-246), Washington (May 1972).

gas-turbine topping cycle.[19] This may be the best long-range possibility for burning coal in central power plants; and indeed a 170-Mw pilot plant embodying these principles is now in operation in Germany. However, this technology is complex, and it might be quite difficult to convert existing power plants to low-Btu gas burners, especially with gas-turbine topping cycles. In the U. S. the Commonwealth Edison Company is installing low-Btu gas generators at its 120-MwE Powerton Station, though without topping turbines. The plant is expected to start operating in 1975. We would recommend that this approach be maintained as a strong contender, though we should not depend on it until well into the 1980s.

b. Guarantee and expand our nuclear option

The U. S. is now committed to about 1.3 x 10^5 MwE of light-water reactors by 1980. By 1985 nuclear energy based on burner reactors is expected to furnish about 19 mQ/yr, almost as much as our total predicted domestic petroleum production (22 mQ/yr). Thus our Nation has committed itself all but irrevocably to nuclear reactors as a primary element in our overall energy system. Yet at the same time that the commitment has been made, increasingly strident voices are raised concerning the technological, environmental, and social validity of the entire nuclear energy system. These concerns are manifested in the extremely lengthy procedures now required to license reactors; in the anti-nuclear bias that is so often expressed in the press; in the deferred decision on the future course of nuclear energy decreed by the Swedish Government; in the attempts to declare moratoria on nuclear power in various states in the United States.

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[19] Despite its higher power cycle efficiency, more coal will be required per kwhr because of losses in the gas-producing process. A process that allows coal to be burned directly will use fuel more efficiently overall.

Although members of the energy community, and particularly the nuclear community, take for granted our dependence on nuclear power for a sizeable share of the central generating system, it is not inconceivable that between now and 1985 our society might turn away from nuclear power. Such action would have the most profound economic and social consequences: we simply cannot tolerate a loss of perhaps 50 percent of our central generating capacity. We therefore conclude that the highest priority, equal to that given to guaranteeing our coal option, must go to guaranteeing our nuclear option.

Many of the actions required to insure our nuclear option do not require new inventions: in particular, we must provide some $30{,}000 \times 10^3$ kg of separative work capacity by 1985 if we are to fuel the 300×10^6 kwE of LWRs that are expected by then. An equal amount of separative work would be needed to provide the projected demands of foreign nuclear reactors, and some of this hopefully will come from the U. S.[20]

If HTGRs come in by 1985, the separative work required will probably not change too much. An HTGR loading requires initially, per MwE, 1.5 times as much separative work as does an LWR. However, later loadings require 1.3 times less separative work since the HTGR conversion ratio is considerably higher than that of the LWR.

The huge projected foreign demand for separative work obviously presents the United States with an opportunity to reduce the unfavorable trade balance caused by importation of foreign oil. The gain is significant

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[20] The potential separative work capacity of all plants in the United States now is about $27{,}000 \times 10^3$ kg, assuming cascade improvement and cascade upgrading; actual capacity now is $17{,}000 \times 10^3$ kg.

but small. If, for example, 50 percent of the 30,000 x 10^3 kg of separative work required in 1985 by foreign nations (outside the Communist Bloc) were provided by the United States at \$50/kg separative work, this would amount to about \$0.75 billion in foreign exchange. This is to be compared with the \$6 to \$10 billion for imported oil which is our estimated outlay if we reach our target of 8 to 13 mQ/yr of imported oil by 1985, and the oil out-of-pocket cost is 80¢/MBtu.

Though it would be preferable to guarantee our supply of domestic uranium ore, this is not so important as far as trade balance goes, since nuclear fuel, per MBtu, is cheaper than is oil. For example, uranium at \$15/lb and 1.1 percent burnup (this assumes plutonium recycle) represents energy at only 7¢/MBtu; this is to be compared with crude oil in 1985 at, say, \$1/MBtu. Thus the \$25 billion per year trade deficit predicted for 1985 if we imported 30 mQ of oil annually (rather than the 8 to 13 mQ which is our target) would be reduced drastically if uranium energy could be substituted for all this oil (which unfortunately is not possible). Perhaps a more important consideration is that uranium is found in many parts of the world; oil is predominantly found in the Middle East. Thus replacement of oil import by uranium import is politically advantageous.

It is important to remember that, if we depend on LWRs, we may be in environmental trouble before the overall price of nuclear power goes too high to compete. To be sure, the total fuel cycle cost of an LWR increases by only about .06 mill/kwhr/dollar/lb of U_3O_8. Even if the U. S. had to depend on uranium from Chattanooga shales at \$70/lb of U_3O_8, the increase in cost of nuclear power would be around 4.2 mills/kwhr. This corresponds to an increase of about 40¢/MBtu in fuel cost, or \$210/kw increment

in capital cost. However, mining the Chattanooga shales would devastate some of Appalachia's most beautiful hills. At this price, or less, we are supposed to have more than 8 million tons of U_3O_8.[21] At 1.1 percent burnup (plutonium recycle) these uranium resources would amount to about 7000 mQ: this is about 350 times the amount of uranium our scenario predicts we shall be burning in 1985. However, the inventory needed by 1985 must be considered, and this will require about 150,000 tons of natural U_3O_8. If this inventory is pro-rated to each year according to the projected increase in installed capacity, this will require, all told, about 70,000 tons of U_3O_8 in 1985.[22] At $15/lb or less (which would increase fuel cycle cost by 0.6 mill/kwhr), we are supposed to have 1.5 million tons of U_3O_8 or 1100 mQ of uranium[23] - i.e., 20 times our projected U_3O_8 requirement in 1985. This could mean that by the turn of the century we might have to depend on imported uranium.

The world supply of uranium at $15-30/lb is not really known; Johan Brinck of OECD estimates the ultimate resource at between three to five times present cost to be more than 300 million tons![24] Others place

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[21] USAEC Office of Planning and Analysis, WASH-1139 (72), "Nuclear Power 1973-2000", Table 12, p. 14, U. S. Government Printing Office, Washington (December 1, 1972).

[22] Ibid.

[23] USAEC Division of Production and Materials Management, WASH-1243, "Nuclear Fuel Resources and Requirements", U. S. Government Printing Office, Washington (April 1973).

[24] Johan Brinck, "MIMIC", EURO-SPECTRA X, 46-56 (June 1971).

the non-Communist world reserve of U_3O_8 at costs of less than $30/lb at 6 million tons or 6000 mQ.[25] The resolution of this enormous discrepancy between Brinck's estimate and the lower figure is a matter of great importance. If Brinck is right, the incentive to develop breeders before, say, 2000 is weaker than if the lower estimates are correct.

It would be incorrect to infer from this that our projected requirement of 70,000 tons of U_3O_8 in 1985 is assured. There is a great difference between uranium in the ground and uranium that has been mined and milled. The largest amount of U_3O_8 ever extracted in one year in the United States was about 18,000 tons in 1962; in 1972 this number was 14,000 tons. We are therefore counting on increasing our uranium extraction fivefold by 1985. Whether market forces are sufficient to achieve this increase is difficult to predict. At best, one cannot be complacent about the ore situation; at worst, one could predict a shortage of uranium ore in 1985 that would jeopardize our nuclear commitment and, indeed, resemble the oil shortage we are now experiencing. We therefore urge very high priority be given to whatever measures, such as requiring firm ore commitments at the time a plant is licensed, that would remove uncertainties in the uranium market and help forestall a uranium shortage in the mid-1980s.

We mention also the increasing importance of thorium. As the price of uranium rises, a competition will develop between uranium- and thorium-burning reactors. This will not affect the situation too much in the short run since thorium reactors will be started up on ^{235}U or ^{239}Pu, both of which depend on uranium. In the long run, it is clearly essential to advance thorium-burning

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[25]For example, National Petroleum Council, "U. S. Energy Outlook, An Initial Appraisal 1971-1985", Vol. II, Washington, D. C. (November 1971).

technology to the level of present uranium technology. In much of our thinking we seem to have discounted thorium despite the fact that thorium, in total, is a more abundant element than is uranium.

We must streamline our licensing procedures so that a nuclear power plant can be on-line in much less than 10 years. Perhaps most important, we must adopt a more rational policy for siting nuclear power plants. At present, sites for nuclear power plants are chosen in much the same way as are sites for conventional power plants: one decides to put a nuclear power plant at a place where cooling water is available and from which electricity can be distributed conveniently. But a nuclear reactor is not simply a replacement for a conventional boiler: a nuclear reactor requires many subsystems (either on- or off-site) - chemical reprocessing, waste disposal, security against diversion, security against sabotage, control of radioactivity - that either do not exist or are quite unimportant in a conventional power plant. For this reason, siting of a nuclear power plant must take into account far more than optimization of electrical distribution. These complexities in the siting of nuclear reactors have been recognized in France, perhaps more clearly than in the United States. Recently France has selected 10 coastal sites for nuclear power parks; the electrical capacity at each site is expected to reach 4000-5000 MwE by 1985 and to grow to as much as 20,000 MwE by 2000. The main point is that a commitment is being made to confine high-level radioactive operations to certain limited portions of the country, rather than allowing them to proliferate throughout France.

We believe that a similar commitment ought to be made in the United States: that a limited number of places in the U. S. ought to be designated as suitable for nuclear reactors and their subsystems. The number

of such sites should be relatively small, perhaps 200 total. There have been many discussions of the advantages and disadvantages of such nuclear parks. The main advantage is that by confining radioactive operations to relatively few places one minimizes the consequence of an inadvertent release of radioactivity, and one minimizes transport requirements and therefore the possibility of diversion of nuclear material. Moreover, the park will be operated by many experts who are on-site; everything from construction of the plants to dealing with emergencies will be in the hands of highly knowledgeable people. This would add to the safety of nuclear power plants.

Whether the reactors themselves should be placed underground is a matter on which there is considerable debate. This question, along with the matter of off-shore siting, needs clarification as soon as possible. But a major decision, and one that cannot be delayed since it so strongly affects the entire nuclear commitment, must be made with respect to the siting of nuclear reactors. Such decisions will require us to know, for example, the maximum number of reactors that can be clustered in a single site. This will require research on the local dissipation of heat, and on the wheeling of large blocks of electricity. In view of the importance of the decisions concerning reactor siting, including undergrounding, we urge that very high priority be given to those elements of R&D that might help clarify these issues.

Two remaining elements of primary concern that may endanger our nuclear option center around reactor safety and waste disposal. The recent AEC action to establish reactor safety research as a strong, independent entity is a very welcome move. We would recommend that this research be elevated within AEC to the highest category of priority. Of almost equal

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importance is the work on waste disposal, though here most of the shorter term questions have been laid to rest by the current plans for solidification, temporary vault storage, and geological disposal. Yet the country cannot be oblivious to the heavy long-term social commitment implied by energy from nuclear reactors, even reactors of the current generation. R&D that would lead to unleachable solids in which wastes could be incorporated would reduce this social commitment; such development is an important part of the SRP since a publicly credible resolution of these questions at the earliest possible time will do much to insure our nuclear option.

c. Expand geothermal

Geothermal electrical plants based on hot steam in the United States now generate 298 MwE, with plans for additional 404- and 510-MwE units.[26] It has been estimated that as much as 3000 MwE of geothermal steam can be tapped with readily available techniques, presumably by 1985.[27] Such expansion is certainly desirable; but, since it represents only one percent of the 1973 installed electrical capacity, geothermal cannot make a serious contribution to the achievement of our short-term goal.

2. <u>Substitute electricity (and heat) generated without oil or gas for end-uses that now use oil and gas</u>

A second major approach to lessening our dependence on oil would be replacement of oil by electricity generated by coal or nuclear sources; or replacement of oil heat by heat produced from the sun. The most important <u>ultimate</u> possibility is an electrified transport system; but this will not

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[26] National Commission on Material Policy, "Material Needs and the Environment Today and Tomorrow", pp. 5-19, U. S. Government Printing Office (5203-00005), Washington (June 1973).

[27] <u>Ibid</u>.

be available by 1985, and must be rejected as part of the SRP. Much more realistic would be the use of electricity (heat pumps) generated in central power plants for space heating.

a. Space heating, electrical and solar

In 1970 about 12 mQ/yr of oil and gas was used for residential and commercial space heating. The total demand for energy for space heating by 1985 is expected to increase to 19 mQ/yr. By electrifying all of our space heating we have, theoretically, the possibility of making a larger impact on our oil imports than can be made merely by replacing oil and gas that is now burned in power plants with clean coal or uranium. From this point of view alone, electrification of space heating is a theoretically attractive alternative for reducing our oil imports.

This path has drawbacks, however. Most important, electrification of individual dwellings requires individual decisions; it is a course that can hardly be legislated or achieved by Government ukase. Though the technology is available, it is a technology that to be implemented requires many people to make separate decisions.

Here the market mechanism will surely operate. If the cost of electrical heating is right, there will be incentive to shift from oil or natural gas to electricity. At present the energy cost of heating a dwelling in Chicago, if electricity costs 1.2¢/kwhr,[28] by an electrically driven heat pump is about the same as the cost of heating with gas at 91¢/MBtu.[29] Total requirements for fuel are also about the same. For more southerly

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[28] Published 1970 Federal Power Commission (FPC) rates for total electric homes. See also, "Heat Pump Prospects Show Sharp Gain", ELECTRICAL WORLD 180, pp. 80-82 (August 15, 1973).

[29] Average cost of residential gas in the United States.

locations, the electrical heat pump is both cheaper and uses less fuel. Thus from the point of view of large-scale R&D, whatever can be done to keep the cost of generating central station power low will help bring into play market forces that would tend to electrify our space heating system, and thus reduce the pressure on foreign oil and gas imports.

Another possibility that could make some impact by 1985 is solar heating of houses. Individual solar heaters are rather well developed now; absorption air conditioning based on solar energy, however, requires additional development.

Solar heating and cooling[30] for individual houses represents technology which, on the whole, requires rather little R&D. The main problem is the social acceptance of this energy modality, especially in the face of the high initial cost of such installations. Interest rates on home loans are now very high (10 percent compared to 4 percent in the 1950s), and construction costs are rising rapidly. Both these factors militate against rapid adoption of solar residential heating.[31]

When one considers the large change in individual housing taste required if residential solar energy is to be used widely, one doubts that solar energy can make much impact by 1985. The OST Panel suggests solar heating could provide 8 percent of the heating and cooling requirements in new buildings in 1985, 40 percent in 2000, and 70 percent in 2020.

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[30] Actually absorption air conditioning substitutes for electricity which, by 1985, will probably not be generated with oil and gas to any great extent.

[31] A solar home in Washington, D. C., in the 1960s cost $2500 more than a conventionally heated home and provided two-thirds of the required heat. Built today and financed at 10 percent, the annual cost would be about $500; the saving in fuel would amount to around $150/yr.

These are desirable goals, but hardly qualify solar energy as a significant part of the SRP, or for that matter allow us to count on solar to make a serious impact on our use of energy by 1985.

b. Other modalities: transportation and industry

The other possible substitutions of electricity from central generating stations for systems using oil and gas that could conceivably make a difference by 1985 are mass transport and industrial heat. In the former case, primary barriers are the heavy capital and the long lead times required;[32] no impact on the 1985 oil requirement can be expected from electric mass transport systems. At present our transport system uses 15 mQ/yr of oil; by 1985 this is estimated to rise to 28 mQ/yr.

As for oil and gas for industry, we presently use 12 mQ/yr; by 1985 this is estimated to rise to 17 mQ/yr; hence this sector could be very important if coal or a derivative of coal instead of oil and gas could be used in it. About two-thirds - i.e., 11 mQ by 1985 - of the industrial demand for oil and gas is for on-site production of process steam and electricity. By 1985 some fraction of these requirements could be furnished from central power stations or from facilities that have been converted for coal-firing.[33]

Just what this saving could amount to is difficult to say. If all of the on-site steam and electricity were shifted to coal or coal

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[32] Tentative planning for BART began in 1957; the system will be in full operation in 1974 - 17 years later; its impact cannot yet be accurately predicted. On the other hand, more extensive use of buses would save oil, without entailing a large capital outlay if bus load factors could be increased significantly.

[33] In addition, as energy prices rise and as controls on effluents are imposed, it is reasonable to expect that industry will increase its efforts to: recover heat from low-temperature waste streams; install processes that are more energy-efficient as plant expansions occur; and recycle a larger fraction of scrap materials (paper, steel, aluminum) with a corresponding reduction in energy use.

derivatives, the saving in 1985 would be 11 mQ/yr (according to the JCAE scenario). However, we consider this to be an ambitious goal and so we would, admittedly arbitrarily, place a maximum of 3 mQ/yr on savings achievable by shifting industrial processes from oil and gas to coal and its derivatives. Our preference for a lower figure is based on our belief that industrial heat is characteristically generated in many small units, and it is harder to convert many small units to a new modality than it is a few large ones (like central power stations). However, we concede that this view is conjectural; and its validity strongly affects the overall strategy with respect to synthetics from coal.

3. Produce more domestic oil and gas

a. Conversion of coal into gas and oil

So much has already been written on this subject that we shall confine ourselves only to the basic R&D issues. These appear to be:

(1) Relative importance of syncrude and syngas.

(2) Impact of a big-scale commitment to synthetics on requirements for capital and on coal mining.

(3) Are synthetics properly part of the SRP?

(4) The role of boiler feed from coal.

Relative importance of synthetic gas (syngas) and synthetic oil (syncrude)

To make syngas (methane, largely) from coal one must add about three hydrogen atoms to each carbon atom; to make syncrude - i.e., refinery feed stock - one or less hydrogen atom needs to be added. Since a very expensive step in coal hydrogenation is the initial production of hydrogen, syncrude per Btu basically ought to be a cheaper product than syngas. Moreover, syncrude utilizes more of the original energy in the coal than does syngas. According to the Institute of Gas Technology[34] syngas represents only 66 percent of the original energy

[34] An Assessment of New Options in Energy Research and Development (Section D. Clean Fuels from Coal), National Science Foundation, AET-9, Washington (November 1973).

in the coal from which it is produced; syncrude represents 75 to 85 percent of this energy. Offsetting these advantages, syncrude must be further refined and syngas is a higher value product for many uses.

There is rather little difference in capital cost between syngas and syncrude plants of the same capacity.[35] Per MBtu, syncrude ought therefore to be somewhat cheaper than syngas as well as being less sensitive to the price of coal.[36]

Liquid fuel is more versatile than gas: it is used for both transport and heating, whereas gas is used primarily for heating; it can be easily stored whereas gas must be used essentially as it is produced. (We ignore central power generation since we assume that clean energy from coal will be available for this purpose.) However, the main argument for a priority for Federal R&D for syncrude is that the risk to private investors is much greater for developing syncrude than it is for syngas. This is because foreign oil production and transport costs are low relative to the selling price of oil. In contrast, the high cost of liquefying and transporting LNG are well known and present an easier target for private enterprise to evaluate and compete with. Thus a rational plan is for the Government to underwrite the R&D needed to liquefy coal, but perhaps limit its role in syngas development to economic policy sufficient to encourage private undertakings. There are further reasons for favoring syncrude development: We

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[35]Capital Costs for Syngas and Syncrude Plants (1971 Dollars)

Syngas	\$800-1200/MCF/day	or	\$800-1200/MBtu/day
Syncrude	\$5500-6000/bbl/day	or	\$950-1030/MBtu/day.

[36]We estimate, on the basis of the Institute of Gas Technology figures:

$$\text{cost/MBtu} \cong 50¢ + .07 \times \$/\text{ton coal} + \text{O\&M for syngas}$$

and

$$\text{cost/MBtu} \cong 50¢ + .05 \times \$/\text{ton coal} + \text{O\&M for syncrude.}$$

These estimates are based on 15 percent capital charge.

now obtain our gas from Canada, and in the future we expect to get it from the USSR, Algeria, Iran, Equador, and Nigeria; syngas can be made from syncrude; deep drilling in the United States is more likely to produce future supplies of gas rather than oil; and, finally, development of syncrude processes and equipment may well give the U. S. an opportunity to export technology.

We will require 6 mQ/yr of syngas by 1985 if we are to supply our projected demand without import, according to the JCAE scenario. If the demand for oil imports in 1985 is provided by syncrude, according to the JCAE scenario, this would require 29 mQ/yr of syncrude by 1985: this, however, is almost surely an upper limit since one would expect various other modalities - electric space heating, in particular, as well as conservation measures - to come into effect by then. Moreover, according to our assumed goals, we shall allow 15 to 25 percent of our total demand for oil and gas in 1985, or 11 mQ to 18 mQ/yr, to come from foreign sources. This reduces our domestic requirement to 1 to 3 mQ/yr syngas and 16 to 21 mQ/yr syncrude. As far as R&D policy goes, this argument would assign higher priority to developing syncrude than syngas, though both systems will probably play a role by 1985.

Required capital investment and coal mining

Assuming $1000/MBtu/day for syngas and for syncrude, we estimate (1971 dollars):[37]

To produce 1 to 3 mQ/yr syngas requires	$3 to 9 billion
To produce 16 to 21 mQ/yr syncrude requires	$48 to 63 billion
Total for 17 to 24 mQ/yr	$51 to 72 billion.

If prices escalate five percent per year, this amounts to an investment in

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[37] These estimates are probably too low; present estimates (1973) run around $1600 to 1800/MBtu/day.

1985 dollars of about $130 billion to provide the entire projected increase of fluid fuel required to keep our foreign imports to 15 percent of the total demand. The capital investment seems large, but it is not impossible.

To produce 1 mQ/yr of syngas requires 60 million tons of coal/yr; to produce 16 mQ of syncrude requires 730 million tons of coal/yr - a total of almost 800 million tons of coal annually. Thus to satisfy our minimal demand for coal in 1985 for all its uses including hydrogenation (800 million tons), conversion of 5 mQ of residential, commercial, and industrial oil and gas uses equally to coal and nuclear (90 million tons), and 24 mQ of other uses of which most is electric generation (910 million tons), we would have to triple, to 1800 million tons/yr, our coal mining capacity between now and 1985! This on the face of it appears to be very difficult, but may be possible if a major effort to launch such an expansion is undertaken.[38]

To us a more reasonable goal might be to increase 2-1/2 times our current coal production rate by 1985 to 1500 million tons/yr. This would place a limit on our extraction of synthetics from coal to perhaps 6 mQ/yr (this would require a rather higher ratio of syncrude to syngas than we have previously assumed), and would require a capital investment of about $18 billion (1971 dollars). The remaining shortfall would have to be taken up by conservation, increased domestic oil and gas production, and nuclear energy.

It is worth noting that even this goal - 6 mQ/yr by 1985 from coal hydrogenation - is considerably higher than the goal projected by the Institute of Gas Technology for 1985: around 3 mQ/yr by coal hydrogenation.[39] The capital

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[38] See June 8, 1973, testimony of Carl E. Bagge, President of National Coal Association, before Senate Interior and Insular Affairs Committee, and supplementary material supplied by Mr. Bagge, U. S. Government Printing Office, Washington (1973).

[39] Actually the IGT estimate is 6 mQ/yr for 1990. Our figure is a linear interpolation between zero in 1980 and 6 mQ/yr in 1990.

investment to achieve the 3 mQ/yr by 1985 is computed by IGT to be $10 billion, the additional coal about 150 million tons per year.

Are syncrude and syngas properly part of the SRP?

Whether our projection of 6 mQ/yr or the IGT estimate of 3 mQ/yr or the 12 mQ/yr implied by a tripling of our coal capacity is correct, it seems very likely that coal hydrogenation will play an important role in the relatively near term, and therefore R&D on coal hydrogenation must be an element of the SRP. The aim must be always to reduce the cost of the synthetic product so that it places a reasonable ceiling on the cost of fluid fuel. Here one is faced with the hard reality - that from one ton of coal no more than 3 to 3.5 barrels of oil can be extracted. Thus as the price of coal increases (in part to meet environmental or OSHA safety regulations), so does the price of syncrude. Coal at $10/ton would imply $3/bbl for the syncrude raw material alone: the actual cost of syncrude would probably be at least twice this (at 15 percent fixed charges). R&D aimed at developing methods of coal hydrogenation should of course include demonstrations of the technologies themselves; but it must also be aimed at improving, and possibly lessening, the cost and the environmental impact of extracting coal. It seems imperative that very high priority be given to research aimed at mining coal cheaply, safely, and with minimal impact on the environment. These are essential requirements if we are to mine 1800 million tons/yr of coal by 1985.

The role of boiler feed from coal in industrial processes

The discussion thus far has largely been concerned with syncrude - i.e., a synthetic refinery feed, and with syngas. However, there is an important intermediate possibility that has been pointed out by the Cornell Workshop: convert coal to a lightly hydrogenated, low-melting solid that could be used widely in industrial boilers for industrial heat and locally generated electricity.

We have not made the analysis necessary to estimate how much investment in new equipment such a shift would require. If, say, 11 mQ of industrial energy were shifted to coal and its derivatives, then the transport sector in 1985 would be well taken care of by oil and gas saved from the industrial sector. The technology involved in manufacturing solvent refined coal, or a low-melting solid from coal, is rather different from that required for creating a liquid suitable as a refinery feed stock. If further analysis suggests that such a switch to industrial use of a coal derivative is likely, then the overall R&D strategy may be affected: the SRP should then focus very strongly on large-scale conversion of coal to boiler feed for industrial use, and syncrude and syngas would in that event be assigned rather lower priority in the SRP.

b. Oil from shale, tar sands, secondary and tertiary recovery

The JCAE scenario assumes that shale oil will add 0.2 mQ/yr by 1985; the IGT scenario projects 2.4 mQ/yr from shale oil by 1990. This might correspond to, say, 2 mQ/yr from shale oil by 1985.

The main problems associated with shale oil are its cost and its environmental impact. Assuming 3/4 barrel of oil per ton of shale, a ton of shale contains about 4.5 MBtu compared with the 26 MBtu contained in a ton of coal. Thus large-scale processing of oil shale will require about 5 to 6 times the quantity of mining and associated environmental effects per unit of energy in the form of oil as does coal processing (although this ratio depends on how much rock must be removed to get to the coal).

There are several suggested schemes for recovering oil (and natural gas) by in situ methods that would have relatively small impact on the environment. For example, the Garrett Corporation has demonstrated in situ recovery from oil shale by a method that handles only 25 percent as much rock as is required with conventional methods. If such in situ methods are generally applicable, they appear to deserve an important place in the SRP.

On the whole, it is not clear to us what R&D priority ought to be assigned to shale oil. Plants for extracting oil from shale on a large scale are now operating in the USSR, and it seems that the marketplace will serve to regulate the rate at which oil from shale will come in. The same can be said for tar sands and secondary and tertiary recovery: the techniques are fairly well understood, and the marketplace will certainly operate to bring these sources into being. In other words, the questions here are to be answered by private enterprise and are largely economic, rather than technological.[40] Nevertheless, the inherent potential of oil shale is so large that we would recommend strong Federal intervention if the private sector does not move aggressively.

6. Conservation

Before discussing the role of conservation, let us summarize what savings in foreign oil imports we can expect if the various measures we have suggested are successful. The JCAE scenario projects for 1985 a total of 70 mQ/yr to be supplied by gas and oil. Of this, domestic sources are projected to supply 34 mQ/yr leaving 36 mQ to be made up by imports. What savings can we estimate from our R&D scenarios? Here we shall make three estimates - very optimistic, optimistic, and pessimistic. The very optimistic projection is based on expanding coal mining to 1800 x 10^6 tons/yr, and providing the large amount of coal hydrogenation capacity that goes with it. The optimistic projection reduces foreign imports to 20 mQ/yr from the original 36 mQ/yr; this is to be compared with our original aim of reducing imports to 15 to 25 percent of total oil and gas which would amount to 11 to 18 mQ/yr.

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[40] There is an argument for the Government to develop new oil deposits but not use them for production, except in a national emergency. In this way we could continue to depend on imported oil with less risk.

TABLE II

Assumed Possible Savings (mQ/yr) in Demand for Oil and Gas, 1985*

	Total Possible Savings	Very Optimistic	Optimistic	Pessimistic
1. Oil & gas generated electricity replaced by coal, nuclear, geothermal	6	6	4	2
2. Electrify & solarize residential & commercial space heating	11	3	2	1
3. Other modalities: direct industrial use for process steam & electricity	11	3	2	1
4. Syncrude & syngas		12	6	3 (IGT)
5. Shale oil	—	2 (IGT)	1	0.2 (JCAE)
Total saving		26	15	7
Total foreign import	36	9	20	28
Total foreign import as percent of total oil & gas		13	28	40

*No allowance has been made for large increases in domestic oil and gas production - a hopeful possibility.

Thus on our optimistic scenario we are not quite able to meet the upper limit of our objective. The pessimistic scenario on the other hand reduces foreign imports to 40 mQ/yr - a shortfall of at least 22 mQ/yr and possibly 29 mQ/yr.

Two main points must be drawn from this numerology. First, we must recognize the extremely tenuous basis for each of these predictions. Man simply cannot see very far into the future; and it is misleading to believe that these estimates will in fact prove to be realities in 1985. In particular, we reiterate our uncertainty with respect to what can be done about replacing oil and gas in process heat with coal and its derivatives. Our very optimistic estimate of savings is 3 mQ/yr, whereas a savings of, say, 11 mQ/yr is conceivable. Of the short-term possibilities, it seems to us that the most easily achievable is number one: most oil- and gas-generated electricity replaced by coal, nuclear, and geothermal by 1985.[41] We would reassert that this goal should receive the highest priority in our R&D strategy.

Of other technologies, number four - syncrude and syngas - can make the most difference; and we would give to the demonstration of the appropriate process, together with the necessary developments in coal mining and transport, high priority - second only to that accorded number one. The high priority accorded this development is based not only on its possibility of helping in the short run but also its essentiality in the long run. Eventually, we shall have to convert coal to synthetic fuel.

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[41] The possibility of saving 6 mQ/yr by such substitution of coal for oil is suggested in the OEP report, "The Potential for Energy Conservation, Substitution for Scarce Fuels", p. 20, U. S. Government Printing Office (4102-00010), Washington (January 1973).

Yet there is really a basic difference between numbers one and four. For number one the goal is fairly precise, and there is relatively little question that it can be largely reached by 1985, albeit at considerable expense for new power plants and power plant equipment. With number four, however, we face much greater uncertainty - some technological, but others economic. We may set a target price for synthetics by 1985 - say \$1.50/MBtu; but is it really possible at this time to say which, if any, of the possible technologies will give us syncrude or syngas at \$1.50/MBtu in 1985? Evidently not: it is for this reason that the approach to syncrude and syngas must retain flexibility; this means large-scale demonstrations of several processes before we finally decide which, if any, of these should be the basis for a domestic coal hydrogenation industry.[42]

Our second main point is rather obvious from what has already been said: that <u>there is probably no acceptable way of meeting the goal we have set unless stringent energy conservation measures are taken</u>.

How this can be done without grossly affecting our economy is certainly not easy to visualize. As we have repeatedly stated in this paper, the most effective measures to achieve reduced demand are non-technical: they would probably involve tax policy, public education, limitation on size and horsepower of automobiles, in some cases rationing of our energy. To

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[42] The matter is discussed, in connection with syngas, by H. C. Hottel and J. B. Howard in <u>New Energy Technology, Some Facts and Assessments</u>, p. 136 [MIT Press, Cambridge (1971)], "In view of the magnitude of the final commercial operation ... the nation cannot afford to overlook the possibility that any of the four (syngas processes) may have advantages properly assessable only on a larger scale than ... laboratory research .... The analogous case in nuclear power-plant development has been the retention at great cost during the development stages of at least five varieties of slow reactors and four varieties of breeder reactors, simply because the time lost in going back to a complex process abandoned in an early stage is too great."

devise such policy intelligently is at best extremely difficult, especially since the energy problem is a new one, and there are few, if any, real experts in energy policy. For this reason we restate that R&D in energy ought to include studies - systems analysis, economics, analysis of social and individual behavior - that would deepen our understanding of how we use energy, why our use of energy grows so inexorably, and, possibly, what we can do to dampen this growth. Such studies carried out in many centers - in Government, in universities, in industry - would help create the coherent doctrine with respect to energy and its use which would be so helpful if we had it today.

Of the possible conservation measures, the one with the most payoff is almost surely in transportation.[43] Unless the transport sector uses

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[43]Hans Thirring, in Energy for Man, p. 86 [Indiana University Press, Bloomington (1958)] quotes Ayres and Scarlott, Energy Sources - The Wealth of the World [McGraw Hill, New York (1952)], to the effect that "... 95 percent or more of the energy contained in the original amount of crude petroleum is used not to move the car along the road, but to extract and refine the crude oil; to carry the petrol to the filling station; to heat the water in the radiator and the gas in the exhaust; to operate motor-car auxiliaries; and to overcome friction in gears and tyres". And Ayres and Scarlott go on to say, "The reason such huge amounts of energy are being wasted in the form of liquid fuel (and the reason the idea of wasting still more is being seriously entertained for the future) is that we insist upon operating heavy cars with dangerous and useless potentialities of speed and acceleration. This inclination, which is growing all the time, will do more to advance the end of the fossil-fuel era than any other factor. Higher automotive-engine efficiencies are announced from time to time as resulting from improved engines or superior fuels. But motorists have not realized any increase in mileage, since the potential efficiency increase has been offset by running more powerful engines under lighter partial loads and in hauling more tons of automobile at higher average speed. To take a simple example, a car designed for a maximum speed of 100 miles per hour must have 3.5 times as much installed horsepower per ton as a car designed for a maximum speed of 50 miles per hour. Other things being equal, the fuel consumption is about proportional to installed horsepower.

"Histories written a few centuries hence may describe the United States as a nation of such extraordinary technologic virility that we succeeded in finding ways of dissipating our natural wealth far more rapidly than any other nation. At any rate, we are having a wonderful time doing it." These words, though written 20 years ago, remain true today.

significantly less energy, presumably by reducing the average energy per automobile, we see little possibility of achieving our objective of reducing oil imports to 15 to 25 percent of total oil demand by 1985.

Summary and Conclusions - The Short-Range Program

What, then, can we expect from R&D between now and 1985; what can we not expect? And what priorities would we assign within the SRP in accordance with this assessment?

First, what we cannot expect from R&D by 1985:

1. We can hardly expect technology, by itself, to achieve our goal of maintaining oil imports between 8 and 13 mQ/yr by 1985. Whatever success is achieved will depend largely on reducing demand and our ability to get more coal (as well as oil and gas) out of the ground. Thus high priority must go to formulating acceptable energy conservation measures and to assessing and developing mining and reclamation methods.

2. Energy policy is so complex that even the best analysis and study is ridden with uncertainty. Nevertheless, such research or, perhaps better, serious analysis - of options, of tradeoffs, of technological assessment, of scenarios - must be given very high priority in the SRP.

3. Topping cycles, solar heat, geothermal heat, or advanced coal combustion (including low-Btu gas combined with gas-turbines) cannot make much difference by 1985: they must therefore be accorded a lower priority in the SRP.

4. The transport sector, being our primary user of imported energy, must reduce its demand. This is partly a technological, but more a social and legal, question. We must begin to transform the U. S. from a large-car to a small-car society.

And now, what we can expect from R&D:

1. Near-term technology, on the whole, is better at increasing supply, and hopefully maintaining the price of energy at a reasonable level, than it is at reducing demand. Of particular importance is keeping the price of electricity low compared to that of oil and gas, since this will tend to shift demand away from oil and gas toward coal and nuclear.

2. The simplest, most direct way of increasing our oil supply between now and 1985 is to pump more oil out of U. S. fields. This will surely involve heavy emphasis on secondary and tertiary recovery, environmentally acceptable methods of extracting hydrocarbons from shale, and greatly expanded exploration for new oil and gas reservoirs. Incentives for such exploration would help achieve this end. Plausible methods for extracting oil and gas from shale with acceptable environmental impact probably should receive strong support.

3. Two elements of the SRP must be given the highest priority. These are:

a. Guaranteeing the expansion of our coal option

This requires clean energy from coal by the most direct methods - namely, tall stacks (where feasible) and stack-gas cleanup. We include in this highest priority improved methods of mining, particularly methods that will restore the environment. Low-Btu gas without gas-turbine topping may become a contender by 1985; but this will be hard to judge for a few more years.

b. Guaranteeing our nuclear option

This involves R&D on nuclear safety, waste disposal, siting of nuclear reactors, and on thorium systems, as well as providing additional

separative work capacity, and, above all, assuring an adequate supply of U_3O_8. This may require R&D on mining and exploration. R&D on siting is most important since, in the absence of a rational siting policy for nuclear reactors, we believe the nuclear option may be jeopardized.

4. Synthetics from coal we would place in a slightly lower priority in the SRP since the impact that can be made by 1985 is probably less than our optimistic, let alone very optimistic, projection. This assignment of priority follows from our belief that our coal mining could not be expanded as rapidly as might be desired. If this assumption is invalid, the priority of synthetics would be correspondingly elevated in the SRP. On the other hand, if other substitutions of coal for oil and gas can be achieved (in industrial processes, for example), the priority of synthetics would be reduced correspondingly.

5. Since much of our energy situation arises because of environmental constraints, high priority must be given to establishing the scientific basis for these constraints, and, if possible, to reconciling them with practical considerations. However, we must recognize that establishing acceptable standards for low-level insult is inherently difficult, and often impossible. Too much should not be expected from a crash program aimed at placing emission standards on a firm scientific footing.

B. THE LONG-RANGE PROGRAM (LRP)

We restate, and elaborate, the goals of the long-range program:

1. To gradually decrease our dependence on foreign oil and gas so that the U. S. becomes essentially self-sufficient with respect to these energy sources by some time early in the 21st century.

2. To gradually transform the base of our energy system from fossil fuels to non-fossil fuels - mainly nuclear, geothermal, solar. This might be accomplished within 75 years, say by 2050.

3. To gradually transform the basic modality of our energy system to electricity, if possible. The system would comprise a primary electrical system based on nuclear, geothermal, or solar energy; and a secondary system based on synthetic fuels or electrical storage energized by the primary system.

4. As an intermediate step to 3, the primary electrical system would no longer depend on fossil fuel, but the secondary system would be based on coal hydrogenation.

These are admittedly grandiose goals; and indeed it may be impractical to try to visualize so distant a future. Yet it must be stressed that prime energy is the slowest moving of all technologies. The breeder reactor was conceived in 1943; it is unlikely that it will make a serious impact on our prime energy supply until perhaps the 1990s, almost 50 years later! To try to visualize the energy system 75 years from now, despite the uncertainties, is necessary if we are to conceive R&D strategies for technologies that are inherently so slow moving.

Nevertheless, we must repeat our earlier admonition. The goals of the LRP are uncertain, and the proper technological paths to achieving these goals are also very uncertain. Thus the R&D strategy for the LRP must be more diffuse, broader, and looser than that of the SRP. Many schemes will have to be tried, and one must not expect all of them to succeed. The country must be prepared for a lengthy, expensive R&D program that will have both successes and failures.

Institutions and Strategies

The LRP is just that: a long-range program aimed at achieving long-range and rather diffuse energy goals, and therefore beset with uncertainty. When such inherent uncertainty exists, it seems to us that the proper organization of the research instrumentalities is particularly important in ensuring a satisfactory long-term outcome.

There are two orthogonal views as to how R&D should be managed: on the one hand is the strategic view where one sets out in precise detail the aims and methods for achieving them; one then goes about hiring contractors to carry out the plan. The overall strategy, and even detailed management, is concentrated at the center - i.e., in Washington. Perhaps the best example of this kind of management is the Naval Reactors Branch of AEC: all technical decisions are in the hands of Admiral Rickover and his staff. The system works well where the aims are precise and there are no basic questions of feasibility.

The orthogonal way of carrying on R&D is to set up powerful research instrumentalities, like the AEC National Laboratories, establish aims, and then provide the laboratories with resources, but allow the technical details and the basic decisions as to how these are to be achieved to be worked out by the institutions. The Manhattan Project was an example of this method of conducting R&D. General Groves delegated essentially all technical decisions to laboratories and contractors he trusted; he obtained and provided resources for the institutions to get on with their jobs. In our view, institutions that have the proper tone and commitment are generally better at doing long-range R&D than are centrally dominated bureaus, especially where the aims are imprecise and grave questions of feasibility remain. No man,

particularly if he sits in Washington far from the technical details, can know exactly what the proper course ought to be. The essence of hanging loose in the LRP is to delegate as much of the decision-making as possible to the field - that is, to the people actually doing the work. To the extent that Washington tries to mastermind technical directions in detail, one must understand that inefficiency, even ineptness, will result.

It is for this reason that we would recommend an institutional more than a strategic approach to the LRP. National Energy Laboratories should be established, perhaps by conversion or redirection of existing laboratories; their missions should be worked out in consultation with the central authority; but the laboratories, not the central authority, should be responsible for working out how the mission is to be achieved.

Naturally, competition for funds - i.e., for survival - will develop among the laboratories. This is good, not bad. And indeed, the central authority will always be required to adjudicate between the instrumentalities where conflict arises. But the overriding advantage of delegating the LRP to large, interdisciplinary laboratories is that the centers can create a coherent picture of parts of the energy R&D system that can be more responsive to technical realities than would one initiated in Washington; the centers can mobilize great power; they are obliged to act responsibly because of their desire to survive. The LRP is, particularly in its very long-range aspects, too uncertain to expect its pre-emption by any group of experts working at the center to come up with revealed truth that will stand up over the years.

Relation Between the SRP and the LRP

We have visualized a distinction between the short-range and the long-range programs, depending upon when we could expect pay-offs. This distinction is sharp in some cases, but it is blurred in others. For example, the measures taken to guarantee our coal option in the short run include low-Btu gas; but this is clearly also part of the long-range program, since low-Btu gas with gas-turbine topping could be an important long-range option. On the other hand, some of the measures taken to guarantee our nuclear option - particularly those concerned with safety of light-water reactors - are essentially unrelated to the development of the breeder reactor, which is part of the LRP. Thus some elements of the LRP will be simply continuations and perhaps elaborations of SRP elements; other elements of the LRP will have rather little to do with the SRP.

We are confronted with a practical problem in budgeting: should the short-range program and long-range program be considered separate, and to some degree competing, programs within the entire energy R&D budget; or should they be considered labels assigned to projects as a means of helping decide the priority for each particular project? We see advantages and disadvantages to each way of looking at the matter. If projects aimed at short-range goals are weighed against those aimed at long-range goals, the tendency almost inevitably is for the short-range projects to push out the long-range ones. On the other hand, if short-range projects and long-range projects are assigned separate budgets, duplication between short-range projects and long-range ones becomes inevitable. There is a danger that a project with both short- and long-range impact might fall into a no-man's land with neither program accepting sufficient responsibility for the project to push it to completion.

This blurring may be worse in the coal hydrogenation program than in any other: hydrogenation projects hopefully will make a short-term as well as a long-term impact. On the other hand, the nuclear short-range program and long-range program are rather sharply separated - burners in the one case, breeders and fusion in the other. And the exotic systems are entirely part of the long-range program. We would therefore advocate keeping the short-range program and the long-range program as separate budget entities, and take care of the overlaps and seeming duplications case by case.

There is another, quite different, reason for keeping the SRP and LRP separate, and this has to do with the public's expectation from energy R&D. It would be a grave error to represent the large new energy R&D initiative as a means of alleviating short-range energy shortages. In point of fact, most of the money that is now contemplated for the R&D program is aimed at matters that can make little difference during the next 10 years. To lead the public to believe that R&D will make a great difference in a short time could backfire seriously. Separating the R&D program into clearly defined short-range programs and long-range programs would make it easier to convey to the informed public, and to the Congress, an accurate picture of what one can reasonably hope to get from the R&D program in the short run and in the long run.

Alternative Long-Range Scenarios

When one tries to translate the broad goals of our long-range energy program into specific research programs, one can visualize many possible scenarios depending on how realistically one views what we call the "exotic" possibilities. In the long run (after we have run out of oil and gas) we

recognize five theoretically possible large-scale sources of energy:

Coal and coal hydrogenation

Fission breeder

Geothermal

Solar (including ocean thermal gradients)

Fusion.

Of these, coal is not truly a long-range energy source, though for at least the next century it will be very important. The relative emphasis one gives to R&D on these different possibilities depends on one's estimates - or more accurately prejudices - regarding the ultimate economic, technical, and environmental feasibility of each of them.

In the following we classify the long-range scenarios according to one's attitude regarding the feasibility of the long-range possibilities; each scenario therefore corresponds to a research strategy.

Coal and Breeder Scenario: According to this scenario, coal hydrogenation and breeders will be successful; geothermal at best will be a supplementary source; solar and fusion cannot be counted on.

This we consider to be the most likely scenario, and we would distribute R&D resources accordingly. The bulk of the R&D effort should go into ensuring the coal and breeder options with secondary efforts going into geothermal, solar, and fusion.

The Geothermal Scenario: According to this view, geothermal energy shows so much promise that it rather than the breeder should be the central element of the long-range program. Geothermal, in this scenario, would ultimately be replaced by solar and fusion. We find this view hard to support partly because estimates of the potential geothermal reserve differ by a

factor of 1000; and because there is no proof at this stage that the heat from hot dry rock, on which one would have to depend if geothermal is to be a really important source of energy, can in fact be recovered.

The Fusion Scenario: According to this view, which one often hears in the popular press, fusion will indeed be reduced to practice, say by 2000. The breeder is on this account viewed as an unnecessary, temporary development that will be rendered obsolete by fusion. In the meantime, we shall be able to get along well enough with coal and burner reactors - and, in fact, this is given as an excuse for not getting on with the breeder. This view we have consistently rejected, and will continue to reject until scientific and technical feasibility of fusion has been established.

The Solar Scenario: This is the same as the fusion scenario, except that one substitutes the word solar for the word fusion. Again we cannot take this seriously until there is much better evidence that solar can make a serious contribution either to the production of electricity or the production of synthetic fuels.

The Extreme Conservation Scenario: This is the most pessimistic of all the scenarios, and is most usually voiced by extreme environmentalists. According to this view none of the exotic schemes, except possibly solar, will work. Moreover, the society will eventually reject nuclear energy as being an unacceptable source of energy. As a consequence, the society will simply have to reduce its use of energy - perhaps as much as fivefold. The only merit we see in this scenario is that it brings into such strong focus the importance of energy conservation.

Obviously no one can say which of these scenarios, if any, will turn out to be right. Our own judgment holds with the first scenario, but we concede that we may be wrong; this again serves to emphasize the necessity

of maintaining a flexible, not a rigid, position in the long-range program. Nevertheless, the emphasis one gives to various parts of the LRP is strongly influenced by the basic scenario one accepts. In the remainder of this paper we discuss elements of the LRP from the point of view of those who consider the first scenario to be the most plausible.

Clean Energy From Coal; Coal Hydrogenation

Many of the elements identified in the short-range program for achieving clean energy from coal will have long-range impact. However, the emphasis may well change. The short-range program demands quick, though possibly inefficient and expensive, fixes like stack-gas cleanup. The long-range program can afford to try more approaches, can probably approach clean energy from coal in a more rational manner. Thus low-Btu gas, which is probably marginal in the short-range program, looms with high priority in the long-range program. Again, successful coal hydrogenation, upon which so much of our long-range scenario is based, will already have been launched vigorously in the short-range program. However, if the main immediate aim is to produce a boiler feed rather than a refinery feed, the emphasis may be on a different aspect of hydrogenation in the SRP and LRP. This point is touched upon in Harry Perry's "An Energy Research and Development Strategy" prepared for Resources for the Future, and we quote "Because of the unsettled state of the art for producing either a low-sulfur boiler crude or a syncrude from coal, and the possible close relationship of the technologies, ... funds ... for the coal liquefaction ... would be available for both developments, at least until there was a better understanding of the difference between the technologies."[44] In our view this possible

[44] "Summary - An Energy Research and Development Strategy", prepared under contract by Resources for the Future, Inc., printed for the use of the National Fuels and Energy Policy Study Committee on Interior and Insular Affairs, U. S. Senate, p. 10-57 (September 28, 1973).

difference between the two technologies could significantly affect the allocation of funds for coal liquefaction.

We have already alluded to the great importance we attach to the extraction and transportation of coal. If we are to depend on coal to the degree that seems desirable, we must devote continued and aggressive attention to learning how to extract much more coal without damaging the environment unacceptably, and to transporting it in a rational manner.

Conservation

Obviously energy conservation must be an important element of the LRP as well as the SRP. Here the main technological questions probably center on increasing the efficiency of energy-generating devices, and re-engineering our methods of transport so that less energy is used in moving people and things.

Better utilization of energy in industrial processes might properly be part of an overall plan for conservation. Evidently, as the price of energy increases, industrial processes will tend to substitute other raw materials for energy. We should think that R&D ought to be aimed at the various sectors of the industrial community with a view to encouraging this transition.

Again, however, we repeat our earlier admonition: that energy conservation may be more a social problem than a technological one. Policy analysis and intelligent examination of how and why people use energy must continue to go hand in hand with technological fixes that will ultimately provide us with more efficient sources of energy.

Nuclear Energy: The Breeder and Fusion

The primary question concerning the long-range program has to do with the breeder. We are presently committing more than $230,000,000/yr to development of the LMFBR. This expenditure is consistent with the President's statement to the effect that "Our best hope today for meeting the Nation's growing demand for economical clean energy lies in the fast breeder reactor." Nevertheless, many things have changed since this policy was announced, and it may be useful to re-examine the whole matter, particularly because the LMFBR represents the largest single energy R&D expenditure.

There have always been two, rather different, justifications for development of breeders. The first (and we believe the most fundamental) is that man will eventually require an inexhaustible energy source. Of the possible inexhaustible energy sources - solar, fusion, breeders, and to some degree geothermal - only the breeder seems to be scientifically feasible and technically and economically practical. That we shall ultimately need breeders is generally agreed by all who regard solar and fusion as too uncertain to depend upon.

This justification says nothing about <u>when</u> the breeder will be needed. The second argument for proceeding with the breeder is that, as uranium becomes scarce, breeders will produce cheaper power than converters. The fuel cycle cost of the breeder is perhaps around 1 mill/kwhr, and is essentially independent of the cost of the raw material. Even if the price of uranium increased tenfold, the fuel cycle cost of the LMFBR would go up by no more than 0.4 mill/kwhr. This has a great advantage from the point of view of a utility operator: he can predict with good confidence just what his operating costs will be over the life of the plant. Because the fuel cycle costs

of the breeder remain low, it is unclear why a breeder should become obsolete. In this respect, it is rather more like a hydroelectric power plant than like a fossil-fueled or light-water reactor power plant, both of which become uneconomical as the cost of fuel rises.

This classical economic argument favoring the breeder is clouded by our ignorance of its capital costs. At the time the economic arguments for the breeder were first advanced, the fuel cycle and capital costs for reactors were believed to be roughly comparable. Since then, however, the capital costs have risen alarmingly, and in general the fuel cycle costs are no longer as significant as are the capital costs. This point is brought home by the following computation: Suppose the breeder costs $200/kwE more than an LWR, and the fuel cycle cost of the LWR with U_3O_8 at $8/lb is 1.7 mills/kwhr, the fuel cycle cost of the breeder is 1 mill/kwhr. Under the usual assumptions, the LWR can burn uranium at $50/lb U_3O_8 at the same overall cost as the breeder! Much of the issue concerning the rate at which breeders are needed originally revolved around the matter of how much U_3O_8 was available at, say, $50/lb, or whatever cost would match the increment represented by the difference in capital cost of breeders and converters.

The foregoing tradeoffs have been discussed within the nuclear community ever since 1943 when the idea of breeding was first conceived. The issue will remain unresolved until we know better the difference in capital cost between burners and breeders, and until we have more reliable estimates of the amount of uranium available at prices much higher than the $8 to $10/lb we now consider to be of interest - say around $50/lb.[45]

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[45] The AEC's best estimate of the amount of uranium the U. S. will need to fuel the nuclear enterprise is that given in WASH-1139. By 1985, the "most likely" estimate is 72,000 tons of U_3O_8/yr; the total rate of energy generation by fission by that time is about 20 mQ/yr. Cumulative U. S. demand reaches 10^6 tons of U_3O_8 by about 1990, and another 10^6 tons by about the turn of the century.

There is a third, rather newer thread to the argument favoring the urgent development of the breeder, and this is its environmental impact. It is not so much that the breeder releases less waste heat than the LWR; nor is there any difference in routine radioactivity release since properly operating reactors of any kind release almost no radiation. It is rather that the breeder, because it uses so little raw material, causes very little damage to the mine-lands, whereas the mining required for LWRs that use $50 per pound uranium would seriously disrupt the environment. <u>This impact could be so serious as to make it impractical to fuel LWRs with $50/lb uranium even if the ore were available</u>.

If we take the WASH-1139 estimates, we shall be mining about 70,000 tons of uranium per year by 1985. The most recent estimate (WASH-1242, WASH-1243) of uranium available in the United States at $8/lb is about 720,000 tons, of which 270,000 tons is proved reserve, 450,000 tons is probable reserve. At $15/lb the current estimate of uranium reserves is 1.5×10^6 tons. Thus we can in principle fuel the 1985 nuclear system for 20 years or so with $15 per pound uranium. However, we shall run out of $15/lb uranium by the mid-90s according to the WASH-1139 scenario. On the other hand, if for some reason all this low-cost uranium were not to materialize, we would be in trouble fairly soon. If, for example, the 1985 estimated requirement of 70,000 tons of uranium had to be filled with uranium extracted from 60 ppm ore, some 1200 million tons of rock would have to be handled. This operation is of the same order as the entire coal mining industry! Of course, it must be stressed that it is most unlikely that by 1985 we shall be reduced to mining 60 ppm uranium ores, especially since we are not counting on foreign ores; however, the example does demonstrate how awkward it would be to burn low-grade uranium in burner reactors.

We are thus faced with difficult uncertainties. When we really shall need the breeder depends upon our uranium resources; but just what our uranium resources are we can hardly predict with certainty. One's judgment in such a situation is to a disturbing degree a matter of opinion. Our views are these: We are trying to formulate an R&D program that will provide the technology for environmentally benign, economical energy in the long run. As prudent custodians of our country's future energy position, we would argue that our R&D should prepare for the worst contingency - that is, high demand and relatively little low-cost uranium. Should we find more uranium, all we shall have lost is the discounted value of the money we spent prematurely on R&D; if more cheap uranium is not found, we shall be paying a serious environmental, if not economic, penalty for not being able to burn more than 1.1 percent of our uranium.

Thus we would strongly support the President's assertion of the importance of getting on with the breeder reactor as quickly as possible. It is not so much that we can say with certainty how much we gain by having the breeder in hand five years earlier, although according to the WASH-1139 scenario having the breeder in 1990 rather than 1995 would save more than a million tons of uranium by around 2040. It is rather that the breeder possesses three important virtues: (1) it gives mankind an esentially inexhaustible energy resource; (2) the fuel cycle cost is almost independent of ore cost and therefore can be well predicted over the life of the plant; (3) its environmental impact, particularly in the mining phase, is significantly less than that of the burner. These three considerations taken together suggest that there is greater risk in <u>not</u> having the breeder by the early 1980s when we may need it, than in having it then and not needing it.

Thus we reassert that the breeder project is immensely important: so important that it cannot be allowed to fail. This means: (1) pursuing LMFBR intelligently and aggressively; (2) using technology from Europe and Japan if necessary; (3) maintaining backups to the current breeder. We would, however, insist on the importance of more flexibility in the breeder program than it now possesses. The last point deserves elaboration since it is at some variance with current thinking.

Basically, the breeder program ought to be loosened from its LMFBR straitjacket. This means that the competing systems - GCFBR, MSBR, and LWBR - ought to be maintained as serious backup efforts. This is already being done for LWBR, and to a degree for GCFBR. We believe the MSBR should also be supported, possibly with the aim of building an MSBR experiment if research during the next three years shows this to be feasible.

Practically all the world's breeder efforts are in one basket labeled LMFBR. If something goes wrong with LMFBR, the entire world will be in trouble unless vastly larger amounts of low-cost uranium are found or unless fusion or solar energy are developed. Would it not make sense, then, to view the alternative breeders as insurance policies against failure of the LMFBR? And, as befits insurance policies for the entire world, these projects could be underwritten internationally. We would therefore suggest that MSBR and possibly GCFBR be undertaken as international projects, rather like the Dragon Project for OECD.

To add flexibility to the breeder program will cost money; but nowhere near as much as the LMFBR itself. Indeed, rather than build at Government expense a second and third demonstration LMFBR, we would put these resources into bringing the alternative breeders to a point where rational technological choices could be made among the alternatives, say by 1980.

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Fusion

It has been argued that the breeder can be delayed long enough to allow us to by-pass it entirely and go directly to fusion. This view we consider wrong. Despite the great optimism now expressed for fusion, we still cannot say with any assurance that fusion reactors will ever prove practical. To give fusion a priority comparable to the breeder in the long-range program therefore seems wrong. We would much rather see more attention given to alternate breeders than to fusion, at least until the scientific and engineering feasibility of fusion has really been demonstrated. This somewhat pessimistic assessment of fusion, however, must not be over-interpreted. There is no doubt that very substantial progress is being made in fusion research, and that this momentum ought to be maintained. Just as the <u>possibility</u> of fusion must not be used as an excuse for delaying the breeder, so the <u>probability</u> of the breeder must not be used as an excuse for reducing the momentum of fusion research.

Long-range Questions Concerning Nuclear Energy

Mankind's commitment to fission as an energy source carries with it peculiar social commitments for generations far into the future. These commitments have been discussed in a paper prepared for the Woodrow Wilson International Center for Scholars earlier this year - "How Can Man Live With Fission?" - and we shall not repeat them here. Our main conclusions were that we must examine our fission technology to determine whether there may be certain technological paths that reduce the social burden imposed by fission on future generations. What is needed is a re-examination of our fission technologies with a view to identifying whether we have inadvertently

foreclosed options for future generations. One of the most significant aspects of the matter has to do with reactor siting, a matter to which we have already referred. If reactor siting (and nuclear parks) is important for burner reactors, it is evidently much more important for breeder reactors, for which the chemical cycle is an integral part of the system. The long-range program ought therefore to establish a small group whose job it is to try to identify these very long-range questions that have little immediate economic or technological impact, yet which if not identified early can set our fission enterprise along lines that future generations will find difficult to cope with.

The Non-Nuclear Energy Long Shots

In this category we include primarily solar and geothermal energy. We claim little expertise in these technologies, and so our views must be regarded as those of outsiders.

Solar

As for solar energy, we have been much influenced by Hoyt Hottel of MIT. He and Howard state: "Until new knowledge is available, studies of large-scale power from the sun via the flat-plate collector are a waste of time and money. The need is for better and cheaper collectors and for better photovoltaic cells."[46]

Nevertheless, we confess to being uncomfortable with so summary a dismissal of solar energy; research on solar energy must be maintained as part

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[46] H. C. Hottel and J. B. Howard, New Energy Technology, p. 340, MIT Press, Cambridge (1971).

of the LRP. The better photovoltaic cells or flat-plate collectors Hottel and Howard ask for can be developed only if fairly serious research goes into them.

There have been many estimates of the ultimate cost of solar electricity. Our experience with projected costs of nuclear energy make us highly skeptical of all such estimates. Our view, based on studies made at Oak Ridge, is that the capital cost of a large, flat-plate solar energy plant might be as much as $3000/kw, though one hopes that this figure can be reduced if solar energy ever becomes a large-scale commercial enterprise, or if the technology improves drastically. At $3000/kw, and fixed charges of 14 percent, the cost of solar electricity would be at least 6¢/kwhr - four times what we now believe nuclear power costs.

A fourfold increase in the cost of prime energy would, one supposes, be tolerable in the United States. We spend only eight percent of our gross national product (GNP) on energy, and if ultimately all our energy came from the sun (through conversion to hydrogen, as well as through electricity and direct space heating) we could spend, say, 30 percent or more of GNP on energy. The resulting economic dislocation would be immense but, if it occurred over a long time, it might be tolerable. Underdeveloped countries which use much less energy than the U. S. probably could tolerate such an increase better than we, although the high capital cost of solar energy would be a difficult burden. One dream - large-scale desalting of the sea for agriculture - would probably be forever out of reach if we had to depend on solar energy at 6¢/kwhr as the prime energy source.

As for solar energy for other purposes - home heating, and possibly air conditioning, and water heating - these have already been mentioned as part

of the SRP; we would expect these applications to have long-range implications, and therefore also to be part of the LRP.

Geothermal

We have not much to add to what has been said in many articles and studies. Geothermal based on hot steam is a reality and is being commercially exploited. The main question insofar as the long-range program is concerned is: How much geothermal energy is reasonably recoverable? Here we can do no better than paraphrase the estimates that were made in the OST Task Force study on geothermal potential. These estimates are described there as "conservative". Other estimates exceed these by as much as a thousandfold. Evidently much effort must go into evaluating more accurately just how much geothermal energy we have.

Geothermal Energy Potential in the U. S.

	Identified Reserves	Undiscovered Resources
Recoverable at wellhead (coal equivalent)	10 mQ (3.5 mQ)*	60-120 mQ (10-20 mQ)
Paramarginal in situ (coal equivalent)		4000 mQ (137 mQ)
Submarginal in situ (coal equivalent)		> 40,000 mQ (> 1370 mQ)

*The energy from coal (in mQ) that would be equivalent to the geothermal resource for electricity production is indicated by the numbers in parentheses.

These estimated potential geothermal resources may be compared with the roughly 7000 mQ available in the uranium of the Chattanooga shales (at 1.1 percent burnup). If, because of environmental insult, we confine our use of uranium in burners to, say, $30/lb material, then the total energy is around 2000 mQ.

Thus what is called the paramarginal geothermal resource is perhaps twice the probably recoverable uranium reserve for burner reactors. However, if the geothermal energy is used for producing electricity at, say, 14 percent thermal efficiency for steam at the wellhead down to less than one percent thermal efficiency for aqueous or dry heat in situ, the amount of electricity recoverable from this resource must be reduced from three- to forty-fold as compared to the amount of electricity recoverable from an equal amount of heat energy contained in uranium or coal.

The geothermal resource is certainly substantial, but one must recognize that it is not as large as are solar, fission breeders, or fusion. Nevertheless, it seems clear that geothermal energy is an important possibility, and must be pursued as part of the LRP. The largest geothermal resources reside in hot dry rock. Experiments on hot dry rock are now being conducted at Los Alamos; despite the thermodynamic limitations to the extraction of heat from hot rocks at great depth, we consider these experiments to be important, and we hope that they are pushed vigorously.

Other Elements of the LRP

Other research elements in the LRP, such as ocean gradients, minor sources (winds, waves, wastes), topping cycles, etc., have by now been much discussed, and we shall not try to analyze them in detail. With two exceptions, we do not consider them to be as important as conservation, coal hydrogenation, breeders, solar, geothermal, and possibly fusion.

The first exception is hydrogen. In the very long-range energy system it seems inevitable that hydrogen, or some other synthetic energy source, will play a serious role. Probably the most likely source of hydrogen will

be improved electrolysis - but the thermochemical or biological methods of cracking water ought not to be rejected without further study.

The other exception is improvement in electrical transmission - in particular, the superconducting cable. A successful superconducting cable we find particularly attractive because it would largely solve the problem of transmitting huge blocks of power from the nuclear parks to which we are so partial.

Biomedical and Environmental Aspects of Increased Energy Demand

The biomedical and environmental aspects of the increase in energy demand will surely be of continuing importance. These matters are open-ended; it is doubtful that we shall ever know enough about either the biomedical or environmental impacts of our methods of generating energy to consider these questions closed.

One environmental constraint that must be examined fully is the ultimate limit to man's global production of energy because of overall heating of the earth. There are some estimates which suggest that a fiftyfold increase in man's energy production could cause the polar icecaps to melt. This matter is so important that one clearly must devote serious attention to it. The National Center for Atmospheric Research (NCAR) at Boulder apparently plans to address itself aggressively to this question; we would hope that other institutions as well can look into this and related matters.

Final Observations About the LRP

Our discussion of the LRP is a good deal more schematic than is that of the SRP. This is partly because of our lack of firsthand knowledge of such things as solar energy or geothermal; but it is also because, since

the LRP is long range, on the whole it is difficult to specify goals clearly, or to see ways of achieving these goals that 20 years from now will seem as valid as they are now. The motto for the LRP ought therefore to be: Hang loose.

The two real exceptions to this, in our view, are the breeder and coal hydrogenation. We almost surely will suffer a serious crisis in the early 21st century if we do not have these well in hand by, say, 1985 or 1990. We would therefore urge, perhaps more strongly than any other recommendation, that work on coal hydrogenation and the breeder (including alternative breeders) be given the very highest priority in the LRP.

IV. SOME INSTITUTIONAL CONSIDERATIONS

To conduct energy research on the contemplated scale will require a diversity of management techniques and institutional arrangement. In this section we analyze some of the possible arrangements, though we concede that our views are influenced, and possibly prejudiced, by our association with the National Laboratories of the AEC.

The appropriate institutional and management arrangements for the SRP and the LRP are rather different because the aims of the programs are different: in the SRP we seek to create large-scale, competitive, and effective industries based on technologies which are well along, and in which industry is already engaged; in the LRP we are primarily concerned with establishing whether or not a technology is feasible: only then can we say whether or not industry can be based on that technology.

We have already expressed our views as to the proper way to conduct most of the LRP: by creating coherent, long-term institutions and delegating

to them as much technical responsibility as possible. Most of the LRP - fusion, geothermal from dry rock, solar electricity, the advanced breeders, exotic methods of energy storage and transmission - are still in a stage of prefeasibility. The same holds for most research on environmental and biomedical effects. There is little economic incentive for industry to engage seriously in research on these long shots, yet the Government must pursue them in the national interest. We have previously concluded that National Energy Laboratories - either created anew or by transformation of existing Government or contractor laboratories - would be the primary instruments for carrying out the LRP. These would be supported by universities and by industry, but the National Energy Laboratories would be the primary instruments.

The appropriate institutional arrangements for conducting the SRP, and those portions of the SRP that overlap with the LRP - particularly coal hydrogenation - are more complex. The most important point is that one can hardly establish general abstract principles for guidance: instead, each element of the SRP must be examined in detail and an appropriate institutional arrangement set up for it. We shall therefore examine various elements of the SRP and discuss what seem to us to be appropriate institutional frameworks for conducting them.

The Coal Option

This poses the knottiest problem: considerable expertise already resides in industry, especially with respect to gasification and liquefaction. One then asks, broadly, what should be the relation between Government and industry in coal hydrogenation? In particular, should the Government, in

addition to contracting with industry for research and construction of demonstration plants (each of which may cost as much as $300 million), carry on large-scale research within its own laboratories both as backup for industrially conceived processes and as a means of creating new processes?

All who have examined this matter seem to agree that, though industry must be the primary agent in carrying out the coal hydrogenation program, Government should do enough in-house research to monitor whatever contracting Government does with industry. Government ought also to do much of whatever backup basic research is needed to assure success in coal hydrogenation: this might be done in Government laboratories, in industry, in universities. But considerable doubt has been voiced as to whether Government should establish one or more coal laboratories, comparable in scale and strength to the existing AEC National Laboratories.

The arguments against such laboratories are (1) that the expertise already exists in industry; (2) there would be great difficulty transferring findings from such laboratories into industry; and (3) such laboratories work outside the marketplace and are insensitive to its needs.

These arguments have some merit: but we would point out that the AEC Laboratories have in many instances provided strong counter-arguments. To the argument that Government laboratories work outside the marketplace and are insensitive to its needs one must realize that coal hydrogenation itself will for some time be an uneconomical proposition: in this respect its motivation and relation to the marketplace is not unlike that of civilian reactor development in its early days. The AEC Laboratories have shown themselves to be important elements in the Government-industry partnership that has

developed commercial nuclear energy. In this process the laboratories have generally been sensitive to economics, insofar as economic factors were at all identifiable.

To the assertion that Government laboratory-developed technology cannot be transferred to industry, there are innumerable counter-examples, and we mention only two. The whole technology of refining uranium ore was developed in AEC laboratories, and was subsequently taken over by industry. Much of today's nuclear electronics industry was spun off from AEC Laboratories: in this instance, the spin-off was often a matter of laboratory scientists going into business to develop an idea they had originated as members of the laboratory.

To the argument that existing institutions, particularly the AEC Laboratories, are not acquainted with the technology of coal, there are two counter-arguments. First, the AEC Laboratories have demonstrated their capacity to move into new areas and to make important impact: for example, Oak Ridge became a leading center for development of techniques for desalting water even though it had no prior experience in desalting per se. But the unit operations in desalting are much the same as those required in other processes - mass transfer, distillation, separation of phases, etc. One must recognize that coal hydrogenation also involves unit operations that are familiar to the AEC Laboratories that have engaged in heavy process development.

There is another, more compelling, argument that in our view favors mobilization of AEC-like laboratories in the development of coal hydrogenation. The AEC style of development can be described as "overwhelming the problem". The AEC Laboratories possess a very wide diversity of scientific

and engineering talent. They can launch massive and many-leveled attacks on technical problems: basic research, development, pilot plant, demonstration plant are all done on a large if not expansive scale. By contrast, our impression is that coal hydrogenation projects have tended to be less thoroughly researched before pilot and larger scale plants are built than would be considered appropriate in AEC-conducted development. For example, the total money that has gone into all coal hydrogenation research in the past 20 years in the United States is estimated to cost $140 million, whereas at least six times this amount has already gone into the development of a single reactor type, the LMFBR. It is our belief that coal hydrogenation ought to acquire much more of this characteristic AEC style: that one ought to do more, rather than less, than the minimum required to assure success. Bringing the AEC Laboratories into coal hydrogenation would lend to this development at least some of the far-ranging, large scientific style that we believe should help assure success of our hydrogenation projects.

On the whole, we believe the relation between Government and industry developed in the LMFBR project could serve as a good model for each of the coal liquefaction projects. In both instances the technology is available in principle, but there remain a host of engineering details to be worked out. In both cases the demonstration plant is not economic, yet industry as well as Government shares its costs. In the LMFBR the Government laboratories are strongly involved, though they do not have the prime responsibility; the same kind of responsibility could be assumed by strong Government coal laboratories, possibly based on existing AEC Laboratories.

The arguments which we have given for strong Government laboratories in coal hydrogenation hold for many of the other parts of the coal option,

particularly those where the industry is weak and fragmented. Of these the mining of coal, which is so crucial, is perhaps the weakest and most fragmented. Strong Government facilities that created new coal mining technology would almost surely have important and beneficial impact.

Oil and Gas

Here the Government research instrumentalities are less needed: the oil and gas industries themselves are such powerful entities, and they have demonstrated such strong technical capacity, that there would appear to be little need to back them up with Government laboratories in the short-range program. Still one can see some role for the Government facilities: as, for example, Livermore in connection with in situ gasification of coal or in situ extraction of oil. These, however, may be rather long shots, and would more probably be part of the LRP than the SRP.

Nuclear

The relation between Government and industry in the nuclear enterprise has evolved over the years, and seems to work well. As far as the SRP is concerned, Government tends to confine itself to matters having to do with public health and safety, waste disposal, and regulation. We see no reason to change this basic pattern of Government-industry cooperation.

Conservation

Insofar as technology rather than policy can make a difference in conservation, we see some role for the Government laboratories. For example, the NBS has always played a vital role in developing new technology for the

building industry. It would seem only natural that this be continued with emphasis on construction techniques that conserve energy.

The Role of the Universities

We have said little about the universities - yet it seems clear that they must be mobilized around energy. The nuclear and space projects had serious impacts on the universities. The impact of space has not been entirely beneficial since the space program grew so quickly and then dwindled equally quickly: empty university-based space institutes attest to the troubles these swings have caused. However, we believe the energy problem is fundamentally of much longer duration; that an intellectual community devoted to energy must be created and nurtured; and that the basic science underlying coal conversion as well as other energy sources must be encouraged. We would urge that the new energy program include significant support for university-based research, with a view to creating a broad base of understanding of energy as well as a cadre of experts who will man our energy enterprise.

Systems Studies: An Institute for Energy Analysis

We conclude with the rather obvious remark that coherent thinking about our energy system is essential. Thus considerable effort must go into analysis of energy systems - e.g., projection of demand, identification of demand components, isolation of the many factors that affect use of energy. Much of this work is best done in small groups associated with existing energy laboratories or with universities; and indeed such "think groups" in energy have begun to spring up.

However, it is our belief that a larger Institute for Energy Analysis (IEA) ought also to be established. Such an Institute would serve as a central focus for the development of coherent policy in energy. Though the IEA would be strongly concerned with the strategy of R&D, it would concern itself with more than energy R&D: its theme would be energy, not only energy R&D. Such an IEA would be manned by technologists, scientists, lawyers, social analysts. It would be responsive to the needs of Government at many levels - EPO, OMB, the various agencies with responsibility for energy. Should ERDA be established, the IEA might be an arm of ERDA.

The IEA would, in addition to responding to requests for analyses from Government agencies, be expected to initiate its own analyses. It would carry out technological assessments of new options; it would perform systems analyses; it would establish a strong information clearinghouse; it would help integrate the work of the various smaller energy systems groups. A fully successful Institute for Energy Analysis would create the coherent doctrine with respect to energy that, had it been in existence, might have helped forestall or at least mitigate the consequences of the present energy crisis. But the problem of energy will be with us long after the current crisis has passed: shortages and recurrent dislocations may well become an inevitable part of our lives. To foresee these, to analyze them, to recommend R&D and policy to cope with them, to provide a powerful institutional base to which policy makers will listen - these are some of the things that should come from an Institute for Energy Analysis. For these reasons we would recommend that such an Institute be made a part of the overall energy R&D plan.

U.S. SENATE,
COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C., December 3, 1973.

Dr. DIXY LEE RAY,
Chairman, Atomic Energy Commission,
Washington, D.C.

DEAR CHAIRMAN RAY: In the course of testimony given by Professor P. Auer and Dr. A. M. Weinberg on S. 2744, the possibility was discussed of establishing large production capacity of synthetic fuels by 1980. More specifically, our witnesses pointed out that with essentially known technology the United States might by 1980–85 be able to produce $2x10^6$ bbls/oil per day from oil shale and $2x10^{12}$ cft of pipeline gas from coal. It was estimated that such a program might cost between $\$30x10^9$ and $\$50x10^9$.

It is my belief that this possibility merits a good deal of further study with the aim of implementing it if detailed examination of the matter shows it to be feasible and desirable. In particular, such a study ought to include:

1. Cost estimate of such a project.
2. Probable Federal commitment required.
3. Long term economic feasibility of such production.
4. Additional legislative recommendations which would be needed to implement such a program.
5. Estimates of the Environmental impact of the program.

I am therefore writing to ask the AEC to undertake a study of these possibilities and report the results of this study to the Senate Subcommittee on Reorganization, Research and International Organizations on March 3. I request a preliminary response on the matter by January 15, so that if these preliminary results are favorable, their implications may be incorporated into S. 2744.

Sincerely,

ABE RIBICOFF

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., January 28, 1974.

Hon. ABRAHAM A. RIBICOFF,
U.S. Senate, Washington, D.C.

DEAR SENATOR RIBICOFF: This is in reply to your letter of December 5, 1973, in which you requested that the Atomic Energy Commission undertake a study of the implications of a large-scale synthetic fuels production program. Your specific questions refer to the possibility of producing two million barrels per day of oil from shale and two trillion cubic feet per year of gas from coal.

First, with respect to oil shale, there are several alternatives available to the Government which could accelerate the growth of an oil shale industry. One alternative, supported by some on the basis of the recent bidding for oil shale leases of Federal lands, is to simply let the industry alone to develop its own oil shale production. Other alternatives range from financial incentives; such as guaranteed product price, loan guarantees, or direct loans; priority allocation of resources, such as construction materials and water; and legislative actions, such as streamlining environmental review, and regulatory procedures for first generation plants. Implementation of such actions could result in substantial production of oil from oil shale by the early 1980s. Production at a rate of two million barrels per day by 1980 would create substantial requirements on the local and state governments to provide the necessary support facilities; such as schools, roads, and utilities as the population in the affected region would be approximately doubled in a period of about five years. As with all major new enterprises, careful planning will be required to minimize associated environmental and social impacts.

Second, with respect to synthetic gas from coal, an industry which annually produced two trillion cubic feet of synthetic natural gas would require about two dozen production plants. Each plant would cost about $500 million (1974 dollars) and would use 6–8 million tons/year of coal, which is about 1% of current production. The cost of the gas would be in the range of $1.20 to $1.24 per thousand cubic feet, in comparison to today's price of 30¢ to 50¢ per thousand cubic feet. There are already numerous proposals from utilities and pipeline companies to build coal gasification plants. Thus, there is technology to produce gas from coal at prices that may be competitive in a few years. Although continued Government assistance in developing better gasification processes is important, the major Government aid to establishment of a coal gasification industry appears to lie in

working out problems in the areas of price regulation, environmental restraints on plant siting, coal leasing on Federal lands, mining regulations, licensing procedures, and possible emergency priority allocations of scarce water and steel resources.

As you requested, we will evaluate by March 3, the feasibility and desirability of utilizing these technologies to establish a large production capacity for synthetic fuels by 1980. In determining the proper mix of fuels that would represent the optimum synthetic fuels program, consideration will also be given to coal liquefaction, even though it is in a relatively early stage of development compared to oil from shale and synthetic gas. Therefore, we will undertake a similar analysis of the possibility of producing significant amounts of clean liquid fuels from coal.

Some of the major considerations that will influence our findings are already clear.

Recent oil price increases and proposed increases in natural gas prices will both reduce demand below and increase domestic supplies above what they would have been had former trends continued in an orderly way.

The timing and extent of these supply and demand changes is still very uncertain. Accordingly, it is not now possible to specify with precision how much synthetic fuel production will be needed by 1980 to become self-sufficient.

The exact nature of the availability and cost of imported oil and natural gas in future years is still unclear. Thus, although it is clear that the Nation needs the capability for energy self-sufficiency, it is not now clear how fast we have to move in building synthetic fuels plants to achieve that capability.

There are also wide ranges in the cost estimates of the technical, economic, environmental, and social consequences of synthetic fuels production. There is no commercial U.S. experience on which to base such estimates; it is, therefore, not possible to predict with any confidence exactly how much such synthetic fuels are going to cost the Nation.

This combination of uncertainties as to how much and what kind of mix of synthetic fuels will be needed by when, and what they will cost, poses a serious dilemma. If we do not do anything until the uncertainties are resolved, we risk severe and prolonged energy shortages. Yet, if we immediately launch a program to build large numbers of plants, we risk diverting large quantities of resources from other pressing needs, only to end up in a few years with a number of expensive "white elephants" that are not economically viable.

Our preliminary analyses suggest that the best resolution of this dilemma may be an approach recommended by a number of industry representatives. This approach would structure the total synthetic fuels production program into two phases. Phase 1 would begin immediately, on an urgent basis, to build one commercial-scale plant for each of the most promising synthetic fuel technologies, for a total of some four to six plants. Top priority effort would go to getting these plants on line, measuring the results, and modifying them as required to get production costs down as far as possible as soon as possible.

Phase 2, on which a decision would be deferred until sufficiently precise supply, demand, and production cost estimates could be developed, would be an expanded construction program on whatever scale might be required to attain self-sufficiency. The program would use the best available technologies based upon the experience of the Phase 1 plants. Phase 2 could, of course, be initiated before the completion of Phase 1 if such were required.

This two-phase approach appears to have a number of advantages.

It gets the Nation moving now on creating an in-place synthetic fuels production capability. The implications of the positive action will not be lost on those who now export fuels to the U.S.

Given the limited technical manpower and construction capabilities the Nation has in this area, the two-phase approach probably would slow the ultimate outcome by only a small amount. Depending on what is learned in the first phase, it could well speed up the eventual attainment of self-sufficiency and lower substantially its cost as well. Starting with a few plants, and thoroughly testing the processes at commercial scale will likely prove to be the speediest route to total self-sufficiency.

The two-phase approach postpones the decision to commit to a massive investment program in technologies with which we lack any domestic commercial experience until better information is available.

The principal requirement to get moving on any such program appears to be legislation to expedite (for at least the initial plants) the licensing, regulatory, environmental review, and other procedures required to get approval to build such plants. For example, the issue of whether the initial plants should be granted exemptions from certain existing requirements is one that hinges on perceptions

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of the seriousness and nature of the current and projected energy situation. Some see the situation as so serious that emergency measures to speed up plant construction are fully justified. Others remain unconvinced that present or projected circumstances call for any modification of existing licensing and regulatory procedures.

My own view is that it is in the national interest to undertake Phase 1 immediately. I believe that we should expedite to the utmost the essential reviews for and construction of the first stage plants so as to get them underway and on line as soon as possible. From their operation we can learn more about what procedures should apply to the follow on plants. We can also resolve the substantial uncertainties that will continue to exist until we get some commercial-scale experience. This is the objective of the Synthetic Fuels Pioneer Program set out in my December 1, 1973, report to the President on energy research and development.

We hope this preliminary information is useful and look forward to providing the results of our more detailed analyses at an early date.

Sincerely,

DIXY LEE RAY, *Chairman*.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 8, 1974.

Hon. ABRAHAM A. RIBICOFF,
U.S. Senate,
Washington, D.C.

DEAR SENATOR RIBICOFF: In response to your request of December 5, 1973, the Atomic Energy Commission undertook a preliminary study of the implications of developing a large-scale synthetic fuels production program by the 1980s. Enclosure 1 contains our response to your specific questions relating to the possibility of producing two million barrels per day of oil from shale and two trillion cubic feet of gas per year from coal.

In short, it would be technically feasible, using essentially known technology, for the United States to establish a synthetic fuels production program on the scale projected by Professor Auer and Dr. Weinberg in their testimony before your Committee. The capital investment for the plants for the oil shale program might range from $7 billion to $12 billion, depending on whether they were surface plants or of the in situ type. The total capital investment for the coal gasification program would be about $14.5 billion, including $500 million for each of 24 plants and $50 million for each of the coal mines that would be required.

Under existing environmental law, present technology probably does not permit such plants to be built on the time scale projected. Therefore, a determining factor in accomplishing the formidable objectives may well be the establishment of a single environmental review for each project, or some governmental exemption. An equally significant federal role in stimulating such a program would be in expediting the requisite regulatory and licensing reviews of the plants.

Although the oil shale and coal gasification programs are technically feasible, the desirability of pursuing these near-term options for new energy supply rests on many other factors. Serious difficulties would be expected in obtaining the necessary manpower, materials and capital resources. For example, current price control requirements would probably preclude obtaining the necessary foundry capacity, reinforcing steel and other vital equipment in time to meet the proposed schedules.

As an outgrowth of my December 1, 1973 report to the President on energy research and development, I directed a task force to examine the feasibility and desirability of the following eight energy demonstration concepts that appeared to have potential for near-term energy production:

Government Role in an Oil Shale Demonstration Program (Draft Executive Summary and Draft Report enclosed).

Methanol from Coal for the Automotive Market (Draft Executive Summary and Draft Report enclosed).

Synthetic Fuels from Coal (Draft Executive Summary and Draft Report enclosed).

Regional Demonstration Program for Maximum Use of High Sulfur Coal and Maintenance of Air Quality Standards.

Construction of a Nuclear Power Center.

Solar Energy Program Plan for Heating and Cooling Buildings.

Advanced Reclamation Methods for Western Coal Extraction.

Rapid Deep Drilling Methods.

Enclosure 2 contains a preliminary evaluation of two additional technical options that could also be developed as part of a national synthetic fuels program. The information on syncrude and methanol from coal resulted from the task force study of the eight possible energy production demonstration projects utilizing existing technology.

After the studies were underway, the Federal Energy Office was assigned responsibility for coordinating Project Independence activities, including the stimulation of synthetic fuels production. Accordingly, I forwarded the draft reports to William Simon, Administrator of the Federal Energy Office, for his consideration and possible use in planning for Project Independence. These studies will provide additional input to decisions that will be made in the near future on the most desirable means of accelerating the use of our abundant domestic resources and decreasing our reliance on imported oil.

The Federal Energy Office is currently formulating a plan to implement the objectives of Project Independence. In developing this plan, FEO will consider a number of immediate actions the Government might take to expedite the completion of energy related facilities currently postponed for some reason, including delay due to regulatory problems, possibly resulting from a government action. Consideration is also being given to determining possible incentives the government might use in stimulating private industry to establish a synthetic fuels industry in the U.S. FEO anticipates the plan will include an Early Action Program aimed at accelerating current domestic energy production and reducing consumption.

The cost of synthetic fuels relative to conventional petroleum fuel costs are not well known. Thus, the role, timing and mix of a synthetic fuels production program are some of the most difficult determinations the FEO must make in formulating a program aimed at achieving U.S. energy self-sufficiency. The impact of the efforts of the Early Action Program will provide valuable input for determining the most effective and efficient program possible. The information collected in response to your request and from the eight energy demonstration concept studies will be useful in determining the technical feasibility of various alternatives. I have offered AEC's services to FEO on this important endeavor.

I appreciate having an opportunity to comment on proposed plans for synthetic fuels production. If we can be of further service, please let me know.

Sincerely,

DIXY LEE RAY *Chairman.*

Enclosures:

1. Production of Two Million Barrels of Oil Per Day from Oil Shale and Production of Two Trillion Standard Cubic Feet Per Year of Pipeline Quality Gas from Coal.
2. Preliminary Evaluation of Two Additional Technical Options that Could be Developed as Part of the Synthetic Fuels Program.
3. Draft Executive Summaries and Draft Reports of Three Energy Demonstration Concepts.[1]

ENCLOSURE I

PRODUCTION OF 2 MILLION BARRELS OF OIL PER DAY FROM OIL SHALE

To produce 2 million barrels of oil per day would require approximately 20 plants each of 100,000 barrels per day capacity.

1. *Preliminary Cost Estimate*

If these were all surface plants the capital investment in 1974 dollars for each plant would be $600 million including mining and the total cost for 20 plants would be about $12 billion. If all plants were of the in situ type the capital investment would be approximately $340 million each, or about $6.8 billion for 20 plants. (The in situ process has been demonstrated only on a very small scale.)

2. *Federal Commitment Required*

A major change in Federal land leasing policy would be required in order to implement an oil shale industry of this magnitude by the early 1980's. Some government support, probably in the form of guaranteed loans, guaranteed product price or direct joint government/industry funding for early demonstration plants, will likely be required, particularly for the less developed in situ technology.

[1] Available in subcommittee files.

Other government actions would include priority allocation of scarce resources, such as water, manpower and steel; removal of administrative constraints; and possible assistance to state and local governments to establish the supporting communities and facilities.

3. Long Term Economic Feasibility of Such Production

If one or more oil shale processes can be demonstrated to operate as expected on a commercial scale the industry should be economically viable at a crude oil price of about $5.00 to $6.50 per barrel.

4. *Additional Legislative Recommendations*

In addition to appropriation, and possibly authorizing legislation, some additional legislation may be required to streamline environmental review and regulatory procedures. A major purpose of a demonstration plant would be to show that the plant could be designed to operate in an environmentally acceptable way.

5. *Environmental Impact*

If all 20 of the plants were of the type that processes the oil shale on the surface each one would require 120,000 tons per day, (assuming shale containing 35 gal. per ton), or 44,000,000 tons per year. The 20 plants would require approximately 880 million tons of oil shale per year which is approximately 1.5 times present annual U.S. coal production. Disposal of spent shale after surface retorting is a serious environmental concern. It may be possible to return some of the spent shale to the mine at increased cost. However, there would be mine safety problems involved in that action and this would only be a limited solution at best due to bulking of the shale during mining. If these were all non-nuclear in situ plants, perhaps as much as 25% of this amount of shale, or 220 million tons, would have to be mined. For in situ retorting in which a nuclear explosion is used to break the shale there would be no mining required. For an in situ process using high explosives to break the shale the mined shale would likely be processed in surface type plants to optimize economics.

The development of surface processing operations capable of producing 2 million barrels of oil per day would increase the population of the region by about 300,000 people. With an in situ process, the number of people would be about 200,000 people. The very large inflex of people into an extremely sparcely populated area will require careful planning to avoid undesirable social, economic and environmental impacts.

For surface processing, approximately 350,000 acre feet of water would be required annually. The in situ process would require approximately 175,000 acre feet per year.

PRODUCTION OF TWO TRILLION STANDARD CUBIC FEET PER YEAR OF PIPELINE QUALITY GAS FROM COAL

To produce 2 trillion standard cubic feet of pipeline quality gas would require 24 plants, each of 250 million standard cubic feet per day capacity operation at a stream factor of 90%.

Each plant would require 6 to 8 million tons of coal per year, depending upon coal quality. Total coal production would be, using seven as an average, 170 million tons per year, an increase over present coal production of 30%. This would require opening up about 50 large mines, probably strip mines. If these were strip mines, this would represent about a 60% increase in coal produced by strip mining.

COST ESTIMATE

In 1974 dollars, capital investment for each coal gasification plant would be $500 million, and each mine would cost about $50 million. There fore, total capital investment would be:

Gasification plants	$500 mill:on ×24=$12 billion	
Mines	$50 million ×50=$2.5 billion	
	Total	$14.5 billion

Cost of gas, in 1974 dollars—$1.20–$1.50 per million BTU

FEDERAL COMMITMENT REQUIRED

Almost certainly government pol cies with regard to licensing procedures and coal land leasing will have to be changed if an industry of this size is to be implemented by 1980. Since the gas industry is regulated, the rate of return of the in-

dustry is assured; no further incentives would be needed. To achieve the proposed time scale, licensing procedures would have to be streamlined; a major Federal coal leasing program would be required; strip mining would probably have to be permitted. It might be necessary for the Federal Government to provide some of the capital in the form of low cost loans or outright subsidies.

The Government might also have to allocate scarce resources to this new industry on a priority basis: these would probably include water, manpower (especially for engineering design and mining), and steel.

LONG TERM ECONOMIC FEASIBILITY OF SUCH PRODUCTION

As a regulated industry, coal gasification would be economic to the producers. Gas from coal would be more expensive than many other sources, including domestically produced natural gas, natural gas from Alaska and Canada, and nuclear gas stimulation. Its increased cost to the consumer could be justified on the bases that its cost is perhaps only 20% more than other alternate gas sources; it is less expensive than LNG or SNG from oil; the U.S. needs the gas, and it is a domestic source.

ADDITIONAL LEGISLATIVE RECOMMENDATIONS

See "Federal Commitment Required". Streamlined licensing and leasing laws, priority allocation of water, manpower and steel, and perhaps legislation for low-cost government loans, all might be required.

ENVIRONMENTAL IMPACT

About 18,000 people would be directly involved in the coal gasification plants and 2400 would be needed to work in the mines. The usual formula is five times the number of workers equals the total population in the area, including families, support facilities, and general community services. The total would then be over 100,000 people involved directly or indirectly in this industry.

A total area of about 36 square miles would be occupied by the coal gasification plants and about 14 square miles per year would be affected by the strip mining operations.

A minimum of 120,000 gallons per minute of water would be irreversibly consumed; this is equivalent to 200,000 acre-feet of water consumed annually.

Considering the overall benefit of the gas produced and the jobs created, the overall impact of this industry could be favorable if adequate environmental controls were strictly enforced. Particular attention would have to be given to strip mining reclamation procedures and to overall health and safety. Standards would need to be enforced concerning particulate emission and emissions of sulfur, nitrous oxides, and other noxious gases. Water pollution control would have to be practiced. Almost certainly the 24 plants and associated mines would have to be well scattered geographically. Any concentration of industry in a single area would lead to decreases in air quality, despite stringent emission controls; to undesirable increases in population; and to excessive comptetion for water, coal, manpower and transportation.

ENCLOSURE II

PRODUCTION OF 600,000 BARRELS/DAY SYNCRUDE FROM COAL

To produce one million barrels/day of synthetic liquid fuels from coal would require 6–12 commercial scale plants operating at 50,000–100,000 barrels/day. Each 100,000 barrel/day plant would require 12–15 million tons of coal per year. A 75 million ton/year increase is equivalent to about ⅛ of current domestic coal production and about ¼ of current strip mining production. 25 to 30 new mines would be required.

In launching a coal liquefaction industry, a choice must be made between basing the industry on today's technology or promising new, but relatively undeveloped technology. The gap between the price of fuel from existing (Bergius and Fischer-Tropsch) and developing (H-Coal and SRC) technologies for the production of clean liquid fuel from coal is believed to be large, on the order of 6 to 9 dollars per barrel. For the purpose of these calculations we will adopt the strategy of building a minimum number (zero) of "white elephant" existing technology plants. Costs below are based on projections of data from bench scale tests of the advanced coal liquefaction processes. In the maximum rate effort described below, where development cost was only a secondary object, the federal government would have to provide substantial backing to insure against the risks of greatly accelerated development.

The first stage of a maximum rate program would consist of the construction of first trains of full-size commercial plants for the two most highly developed of the coal liquefaction processes (the H-Coal process for production of a syncrude and a modified Solvent Refined Coal process for production of a clean liquid boiler fuel). These trains, each processing approximately 10,000 tons of coal per day to produce about 25,000 bbl/day of liquid fuel, would be designed, constructed, and modified in the 3.5 year period from July 1974 through December 1977. A production demonstration would begin about January 1978. The operating costs for the demonstration plants—about $60 million per year for each plant (not providing for recovery of the capital investment) could be provided by selling the oil produced at a price of about $7/bbl.

The second stage of these programs would begin in July 1976 with the design of three commercial plants—each with a capacity for producing 100,000 bbl/day of liquid fuels—for each of the two processes. These six plants, building upon the technology provided in the demonstration plants, conceivably would be producing liquid fuels at a rate of 600,000 bbl/day at a price of $7–10/bbl in 1980.

Cost estimate

In 1973 dollars the capital cost of building 600,000 bbls/day of coal liquefaction capacity would be 3–4 billion dollars. Another billion might be required for the necessary coal mines. Price of the various liquid products would average around $7/barrel.

Federal Commitment Required

The probable development cost (in addition to research funds provided in the $10 billion ER&D program) would be in the neighborhood of $500 million for the demonstration program. The federal government would probably have to pay a substantial fraction of this cost. In addition, it would probably have to provide a guaranteed market and/or low cost loans and/or a price subsidy for several years to persuade industry to build the first full scale prototype plants before 1980.

Long-term Economic Feasibility of Such Production

In light of the recent developments in international oil prices, it is impossible to forecast long-term economic feasibility of synthetic liquid fuels. The projected prices for coal liquids run $7–8/barrel. Domestic oil in now approaching $6/barrel despite the NPC belief stated in their year-old report "U.S. Energy Outlook" that $6/barrel domestic oil would not be here until 1985. The landed cost of international oil is of course now well above $7–8/barrel. However, accelerated domestic and international oil exploration might hold the price of oil level over the long term. Alternatively a serious large effort aimed at synthetic liquid fuel production might cause OPEC to undercut the domestic synfuel price with lower international oil prices.

In summary under existing conditions coal liquefaction is essentially profitable now. Before the Mid-East oil embargo, coal liquefaction was projected (by its proponents) to be profitable in the mid-1980's.

Additional Legislation Required

As with coal gasification plants streamlined licensing procedures and initiation of federal land coal leasing would be required for rapid expansion of coal liquefaction production. Existing and/or proposed laws involving mining would have to be carefully examined for possible inhibitive effects on coal production. Federal economic relief might be required if mining laws proved too restrictive. If manpower and material shortages develop, as predicted, which delayed increases in syncrude production, some legislation regarding priorities of scarce items might be required.

Finally, if it turns out novel methods of subsidizing private development are required to provide a base for a synthetic fuels industry (such as industry bidding on loan interest rates or product subsidy level) legislation may be required to properly channel the money toward the proper ends.

Environmental Impact

Around 12,000 workers would be needed for the coal liquefaction plants and 1,000 for new mines leading to local population increases near plants of about 40,000 people. The plants would occupy 15 square miles and up to 6 square miles of land could be affected by strip mining annually. A total of 60,000 gallons of water per minute would be required for the plants of which 25,000 gallons per minute (40,000 annual acre feet) would be irreversibly consumed.

Since little is known about the effluents from a full scale coal liquefaction plant, immediate research is required to identify and develop control techniques for plant effluents.

PRODUCTION OF 500,000 BARRELS OF METHANOL FROM COAL

It is feasible to produce methyl alcohol from coal on the basis of existing technology at a lower cost than any other liquid fuel. Methyl alcohol can be used directly in automobiles without refining in either pure form, or as a blend with gasoline. Production of up to 500,000 barrels per day by the end of 1980 is feasible if aggressively encouraged and assisted by the Government, and if the supporting R&D in the vehicle application areas is performed and confirms the limited favorable data. This volume would satisfy about 5% of the total gasoline demand.

It appears economically and thermodynamically most desirable to produce pipeline quality gas as a co-product with methanol. Approximately 0.6 to 0.8 trillion cubic feet per year of substitute natural gas could be produced with the 500,000 barrels of methanol per day. Overall, this would require 130 million tons of coal per year or about 20% increase over current production. Producing methanol alone would cut the coal required approximately in half.

Cost Estimate

A 35,000 barrel per day commercial scale demonstration plant would cost approximately $200 million as a single product facility or about $425 million as a co-product plant.

The capital investment required and approximate cost per 10 [6] Btu (both in 1974 dollars) for 500,000 barrels per day are as follow:

Output		Plant cost (billions)	Mine cost [1] (billions)	Total Btu per day	Average cost/10^6 Btu [2]
Methanol	500 (thousands of barrels per day)	$2.9	$1.0	1.4×10^{12}	$2.10–$2.80
Do	Do	6.1	1.9	4.0×10^{12}	1.40–1.90
Plus SNG	Plus 2,600 (millions of cubic feet per day)				

[1] Based upon estimated capital cost of $15,000,000 per million tons per year capacity, large, western strip mine.

[2] Average cost range includes utility financing at the low end and 12 percent DCF industrial financing at the upper end. The range is equal to 9 to 18 cents per gallon of methanol, which because of relative energy content is equivalent to 18 to 35 cents per gallon of gasoline.

Federal Commitment Required

Government sponsored R&D to verify the suitability of methanol for the automotive market would be required on an urgent basis at an urgent basis at an estimated cost of 10 million dollars over four years. Industry may be willing to put up the plant capital in conjunction with a Federal coal land leasing program, but would require some downside product price protection in view of the potential volability of automotive fuel prices. Government policies with respect to permits and licenses would require modification if an industry of this size is to come into existence before the end of 1980. Some priority allocation of scarce resources would also be required.

Long Term Economic Feasibility of Such Production

The January 1974 price range of premium grade gasoline was $1.60 to $2.00/$10^6$ Btu. February figures ranged from $1.75 to $2.75 (22–34¢/gal). The mid 1973 price was about $1.00/$10^6$ Btu. Since it is not possible to forecast future price trends of gasoline accurately, one can only say that methanol appears competitive today. A return to mid 1973 prices would obviously alter this.

Additional Legislative Recommendations

Streamlined licensing and leasing laws, and import duties on methanol and other forms of downside price protection would be required in addition to the item listed under "Federal Commitment Required."

Environmental Impact

There is some indication that use of methanol as a motor fuel will have a positive environmental effect in reducing emissions and minimizing or eliminating the need for tetraethyl lead.

Creating a methanol production industry on the indicated scale would directly involve some 15,000 to 20,000 people for operations. This equates to approxi-

mately a 100,000 population including families, support activities and general community services.

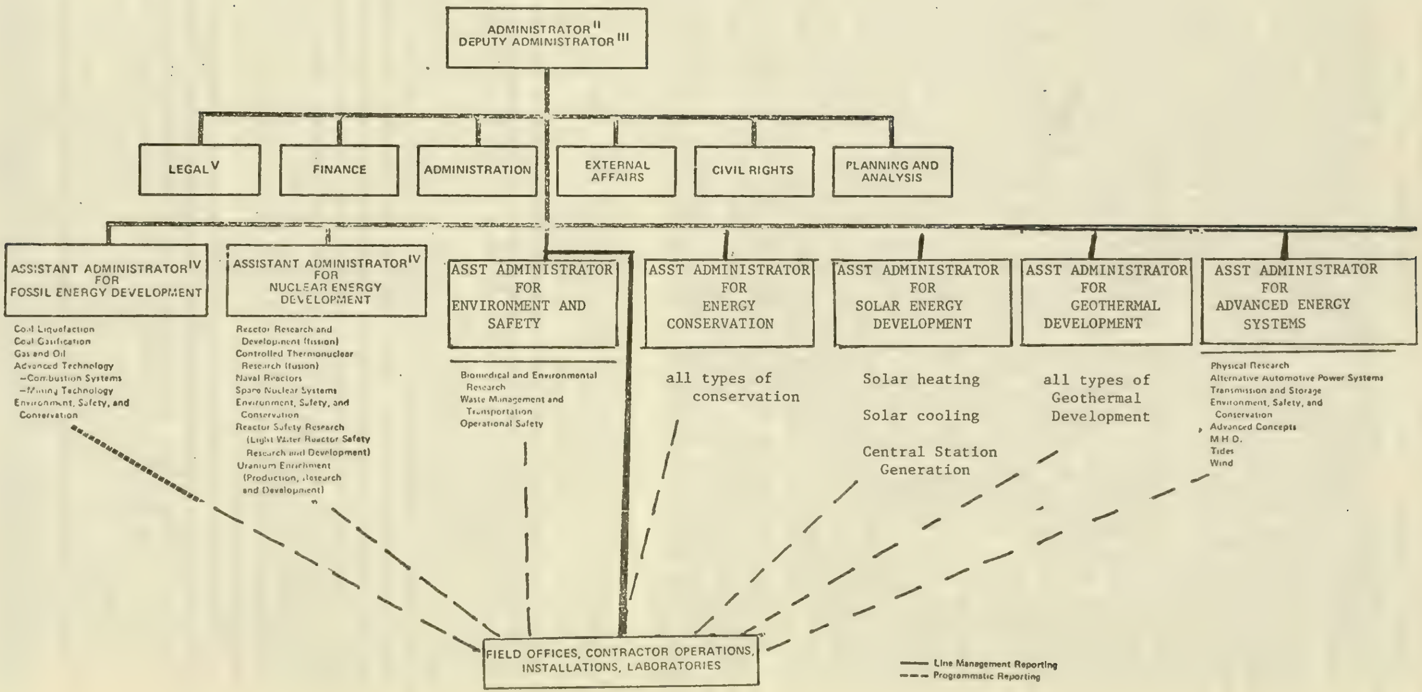
Strip mining operation would affect approximately 10 square miles per year. The plants would consume some 90,000 gallons per minute of water or 150,000 acre feet of water annually.

On the basis of the product produced and jobs created, the overall impact of this industry will be favorable if adequate environmental controls are strictly enforced. Indeed, the net environmental impact may be positive in that methanol exhaust emissions are believed to be lower than those from gasoline. Particular attention will have to be given to strip mining reclamation procedures and water pollution control. Also the plants and associated mines will have to be suitably dispersed geographically to minimize population growth impacts, and excessive competition for local resources.

ALTERNATIVE TO PROPOSED STRUCTURE IN S. 2744

PROPOSED

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION



STATEMENT OF THE AMERICAN MINING CONGRESS, ENERGY RESOURCES POLICY COMMITTEE

Mr. Chairman and distinguished members of the Committee:

My name is Edmund W. Littlefield. I am Chairman and Chief Executive Officer of Utah International Inc., a surface miner of steam coal, uranium, copper, and iron ore in the United States, and coking coal, iron ore, and copper outside the United States. I also serve as Vice Chairman of the American Mining Congress and Chairman of its Energy Resources Policy Committee.

The American Mining Congress is a national association of United States companies that produce most of the nation's metals, coal and industrial and agricultural minerals. It represents companies that produce both nuclear and non-nuclear fuels, and therefore has a very deep interest in this legislation.

We very much appreciate the opportunity to comment on S. 2744, which deals with the creation of the Energy Research and Development Administration and the Nuclear Energy Commission. The American Mining Congress reaffirms its position as presented in my October 17, 1973 statement before this Committee that we support governmental reorganization to consolidate energy research. The present energy situation impels even greater emphasis on the need to further develop our existing energy resources as well as to find new sources of energy.

Our primary concern regarding the reorganization, as proposed in S. 2135 was the provision for only one Deputy Administrator of ERDA, leaving open the possibility that a balance between nuclear and non-nuclear energy research would be extremely difficult to achieve. S. 2744 apparently resolves this problem by providing for five Assistant Administrators of equal status, three of whom would deal directly with energy research. The proper balance is afforded by providing separate, but equal, administrative leadership in research for fossil fuel development, nuclear energy development and "advanced energy systems".

We think it extremely important that any new energy research agency avoid the natural pitfall of "putting all its eggs in one basket", thus failing to develop the full potential of the various alternate sources of energy.

We reiterate that we wholeheartedly support the concepts and reorganization proposed in S. 2744, and think this is an important first major step in providing energy self-sufficiency for the nation.

We thank you for the opportunity to comment on this important legislation and would be pleased to hear from you should you feel we might be of any further assistance.

STATEMENT OF COMBUSTION ENGINEERING, INC., SUBMITTED BY ROBERT M. DRAKE, JR.

The comments and observations which follow express the views of Combustion Engineering, Inc. in regard to and in support of the legislation contained in the Bills S 1283 sponsored by Senator Jackson and HR 11510 sponsored by Representative Hollifield.

It is now abundantly clear to the government, the press, the industry and the general population that there is indeed a severe mismatch in raw energy supply and demand, a development long anticipated and predicted by that segment of the technical community which directs its attention to energy matters. The problem is, certainly, one of grave inconvenience with more than an implication of worldwide economic consequences, but is one of crisis proportions only because raw fuels are not available at either the time and place where needed in support of specific economies. There is, in fact, an ample supply of raw fuels to support a worldwide economy. The current problem can best be viewed as political and economical rather than technical. The longer range problem is rather more economical and technical.

While some countries in the world will have continuing serious dislocation to their economies unless favorable political and economic solutions are reached, the United States is in a better position. We now supply more than 85 per cent of our own energy, and our resources in the raw fuels, coal, oil, gas, oil shale and uranium are such that we can solve our problems and, in time, become totally self-sufficient. To fail now to take the necessary steps leading to energy self-sufficiency for the nation would be a serious, perhaps irreversible misjudgment.

Energy self-sufficiency can be attained in two ways each with different consequences: (1) reduction in overall energy usage, and (2) increase in raw energy supply. Any thoughful assessment and evaluation leads necessarily to the conclusion that in proper ratio both methods must be encouraged. Any coherent

energy policy must stress conservation of energy as well as encourage an increase in availability of raw fuels. Research and development programs directed to improvement in the conservation of energy in the household, commercial, industrial, transportation and the energy processing sectors must receive nearly as much attention as those research and development programs for the creation of new energy sources. To do otherwise is to be completely irresponsible.

Today, in the United States, we are engaged in attempts to solve the energy problem without an adequate definition of the problem, and indeed without a generally accepted national policy on energy. It is quite likely that the cumulative results of any and all activity in the energy areas, undertaken in the continued absence of an overall national energy policy will be destined for limited success, or at worse outright failure.

Any move toward the establishment of a coherent national policy on energy seems more a hope for the future than a prospect for the present, given the political and economic complexity of that undertaking. However, the two pieces of proposed legislation now before the Congress, i.e. the Jackson Bill (S.1283) and the Administration Bill (H.R. 11410) for the creation of an Energy Research and Development Agency, will be the existence of either or both define in part an energy policy. The two bills, superficially alike, are in reality significantly different. And because of the perceived differences each will have a different impact in the rush for energy self-sufficiency. The two Bills can be considered complementary.

The Administration proposal for the creation of Energy Research and Development Administration (ERDA) from the laboratory segments of the AEC, parts of the Department of the Interior, and other presently constituted government agencies, relegating the regulatory and legal functions of the present AEC to a separate Nuclear Energy Commission (NEC) makes sense administratively. However, the budget proposed for the agency, ERDA, would seem to include little if any new money beyond that presently available to existing programs. The research and development program envisioned will continue the major stress on nuclear fission system activities, with inadequate attention to the clean, efficient use of the fossil fuels, particularly coal and oil shale.

The Jackson Bill (S.1283), on the other hand, with a different management concept clearly provides funds for the express purpose of research and development programs for the clean, efficient use of the fossil fuels, as well as for research and development programs of significance for other energy sources such as geothermal, solar and controlled thermonuclear fusion, none of which of course are ignored in the Administration proposal.

Research and development programs notwithstanding, the key to self-sufficiency in energy is synonymous with the rapid commercialization of processes, particularly those processes related to the gasification and liquefaction of coal, and the production of oil from shale, that have been brought through the pilot-plant stage and are ready for commercialization. Energy self-sufficiency will come only through the existence of a large number of conversion plants with outputs in quantities of commercial interest—not by the number of research and development programs in national and industrial laboratories. Furthermore, the translations of pilot-plant processes to plants of a size of commercial interest can best be, perhaps can only be done by the industrial sector, a factor recognized in the Jackson Bill.

The chronic problem of energy insufficiency will remain a troublesome issue certainly for the next decade. The future beyond that will depend upon the effectiveness with which we apply our talents and technological resources to the several problem areas, which when solved will lead to energy self-sufficiency. We have, in fact, because of inattention in the past lost our lead time; but, we need not continue on such a path, further to delay meaningful solutions to the energy problem.

In the Nation's best interest, a rational approach would seem to be the approval of both the Jackson Bill (S.1283) and the Administration Bill (H.R. 11510) accepting the better features of each, i.e. the administrative structure of the latter, and the financial commitment and program emphasis in the former, to produce an overall energy program with the necessary financial strength, administrative structure, industrial involvement and technological resources to accomplish the objectives enunciated as Project Independence.

Statement of Shearon Harris on Behalf of the Edison Electric Institute

My name is Shearon Harris. I am Chairman and President of Carolina Power and Light Company, and Chairman of the Research Division Executive Committee of the Edison Electric Institute. The Edison Electric Institute is the principal

national association of the investor-owned electric utility industry. Its 194 member companies serve about 78 percent of the electric power customers in our nation. The Institute appreciates this opportunity to present to this Committee its views on Federal organization for energy research and development.

Before commenting specifically on the proposals contemplated in S. 2744, I would like to make a general statement regarding the respective roles of government and industry in energy research and development. We believe that these roles will best be determined if they rest upon certain basic concepts.

We believe first of all that the traditional role of equipment manufacturers in research and development relating to the generation, transmission and distribution of electricity should be preserved and utilized whenever this approach will serve the need. The legitimate and compelling incentives of anticipated patent rights and profits from manufacturers and sale may be expected to be productive in the future as they have in the past.

A second category of research and development would involve joint undertakings by manufacturers and the electric utility industry and would fill the need in situations where the incentives are inadequate to permit manufacturers to undertake alone a given research and development effort.

A third area of research and development involves work which can be undertaken independently by the electric utility industry itself. There are occasions when incentives are lacking for manufacturers, but the R&D work in question is of great interest to electric utilities and can willingly be undertaken by them.

There will also be circumstances when research and development can most appropriately be undertaken as a joint effort of industry and government. This will be the case when economic incentives by themselves are not adequate to stimulate a wholly private effort. Government funding will be required, but the industry can contribute financially and from its accumulated managerial expertise.

Finally, there is a fifth category of research and development which can only be undertaken by government itself, and where none of the first four arrangements I have mentioned will suffice. This will most often be the case with regard to basic, long-term undertakings which hold little promise for early return on private investment.

The Edison Electric Institute believes that the nation's energy research and development needs will best be served if we proceed with recognition of these five basic categories. For its part, the electric utility industry has already organized itself, through the establishment of the Electric Power Research Institute (EPRI), to establish priorities and to move forward in the undertaking of needed R&D programs. The existence of EPRI will permit us to pursue R&D programs on our own, as well as to cooperate with manufacturers and with government. And I should note that the efforts our industry is making through EPRI are in addition to the very substantial contribution being made in the national effort to develop the liquid metal faster breeder reactor.

We believe that S. 2744, if properly administered after enactment, would be compatible with the concepts which I have just set forth. The nation's energy needs are such that reorganization of the Federal government for better coordination and pursuit of its energy research and development goals is badly needed. I need not detail for this Committee the proliferation and overlapping of energy responsibilities which characterize the Federal structure at the present time. The establishment of the Energy Research and Development Administration as contemplated in the bill before you would constitute a significant step forward in the reduction of that proliferation and confusion.

We particularly welcome those provisions of the bill which would include among the functions of ERDA the correlation of its own research and development programs with other public and private activities, and the support of cooperative R and D projects involving other public and private bodies. We believe that these provisions are fully consistent with the basic concepts which I described earlier.

We also support the establishment of the Nuclear Energy Commission to perform the licensing and related regulatory functions of the existing Atomic Energy Commission. We believe that the detachment of these functions from the promotional aspects of nuclear power development is salutary and will increase public confidence in the reliability and safety of nuclear power.

At the same time, however, we would hope that a new NEC would work to expedite the licensing process, consistent with the President's recent appeal for a reduction from 10 to 6 years in the time required to get a nuclear power plant into operation. This goal can only be reached if the NEC insists vigorously upon

expedited procedures in all phases of the licensing sequence, including the procedures before atomic safety and licensing boards. And the Congress, as part of its oversight responsibilities, must continually urge upon the NEC the need to streamline and expedite its procedures.

Another point that needs to be made with regard to the future activities of the NEC is that the antitrust review, which is now a part of the licensing process, must not be allowed to delay the operation of needed nuclear power plants. We do not object to the antitrust review in principle. But we do believe that the licensing process should be administered in such a way as to permit the issuance of operating licenses prior to the completion of the antitrust review when that review would otherwise delay plant operation.

In summary, the Edison Electric Institute supports S. 2744 in the expectation that its provisions will advance energy research and development in cooperation with industry and other non-Federal entities, and that the licensing process for nuclear power reactors will be expedited. In comparative terms, we much prefer the approach of this bill to other proposals which would establish government-industry corporations or would simply add nonnuclear management component to the existing AEC.

STATEMENT BY DR. EDWARD E. DAVID, JR., EXECUTIVE VICE PRESIDENT, GOULD INC., CHICAGO, ILL.

It is a pleasure to have the opportunity of commenting on S.2744 which would establish an Energy Research and Development Agency and a Nuclear Fnergy Commission. I support the Bill and its intent, but I have some reservations which deserve mention. Perhaps some of these can be neutralized by changes in the eventual legislation. However, let me make it clear from the outset that action along the lines proposed in the Bill is essential and urgent. It should not be delayed in any effort to incorporate niceties aimed at perfection. If warranted, they can be added by later legislation.

Energy is the hinge point of our society. On it rests our future as the leading nation of the free world. With some 6% of the world's population, we use 35% of the energy, and with that produce 25–30% of the world's goods and services. We are an energy intensive society and will remain so. This dependence on energy is heightened by our resolve to protect the environment and to increase productive use of human resources. Indeed I see the four elements of energy supply, conservation, environmental preservation, and productivity as the four legs which must support the future life style we as a nation desire. All are necessary, though at times they appear to compete. A coordinated, systematic, rational approach to achieving this future depends upon harmonizing all four elements. Essentials in this process are imaginative and creative research followed by resolute and goal-oriented development in the best traditions of U.S. science and technology. ERDA and NEC are well structured to play essential roles in the process.

The proposed structure separates technology development from the licensing and regulatory function which attempts to insure adequate safety and reliability. This is a step forward, for the coupling of these under one agency arouses suspicion, and does not breed confidence that all viewpoints are being aired. Separation avoids even the appearance of "the fox in the chicken coop".

In the proposed ERDA there is a clear designation of responsibility; namely, it resides in the administrator. This is a net improvement over the commission structure which is well suited for the licensing and regulatory role but not for the resolute action that energy research and development require today. I do not believe that the commission form is any longer necessary to provide checks and balances on nuclear weapons programs, if it ever did. Budgetary restraint and independence from the DOD are sufficient to assure a careful assessment of proposed weapons development and production.

The energy problem requires the most competent research and development resources that the nation can supply. The AEC National Labs are, in my opinion, the major strength available for this task. A vital element in their creativity and excellence is the GOCO (Government Owned, Contractor Operated) arrangement. The other laboratory elements incorporated into ERDA should be converted to this system as soon as feasible with the aim of increasing their capabilities.

The weapons labs have important contributions to make to energy research and development. For example, underground tunnelling and operations have become a way of life in the labs testing programs. Much of that technology is applicable to mining and resource extraction. Work on laser-triggered fusion

weapons may be relevant to creation of fusion reactors. Thus it is important to keep the weapons labs within ERDA and I am happy to see that is proposed in S. 2744.

The conjunction of nuclear energy research and development with that on fossil fuels, unconventional sources, energy conservation, environmental research, and resource development is also fortunate for the reasons mentioned earlier in this statement. In addition, trade-offs between various energy related technologies will be facilitated, and that should result in a more balanced research and development program. However, improved balance will not come automatically. It seems essential to establish early in ERDA's existence, target budget ratios for its line organization elements reflecting priorities set according to a national energy policy. This coupling to national policy is essential if development activities are to have adequate focus on specific goals in suitable time frames. ERDA and NEC do not appear to have been charged with this responsibility for coordination, nor have the mechanisms for carrying it out been specified. Additions to the legislation seem necessary.

Also not specified is where ERDA and NEC reside in the executive hierarchy. The importance of these agencies calls for direct reporting to the President. Submerging them within some other department of government, new or old, now or in the future, would dilute their effectiveness.

It is important to note ERDA is a research and development organization. Development of new technology is merely the first step in energy innovation. New technology must be augmented by the necessary capital, construction, and operations before there is any influence on energy supply and demand. In my opinion, these necessities are best supplied by private enterprise, perhaps augmented by government incentives where necessary. This relationship implies a close working relation between ERDA and the energy industry, as well as cost-sharing by industry and risk-sharing by government, when development approaches the commercial stage. The AEC has had considerable experience in these matters in connection with their civilian power reactor program. However, I believe a more active approach to this transfer of responsibility is necessary. I would like to see ERDA specifically charged to investigate various techniques for accomplishing this transfer expeditiously and imaginatively. This may well involve new ways of allowing commercial firms to establish legitimate proprietary rights during the latter stages of development.

So with only minor reservations, I support S. 2744. I believe it or something very similar is an essential first step in meeting the challenge of balancing energy supply and demand, energy usage and environmental restraints, and assuring continued productivity growth.

Statement by Robert Lowenstein, Counsel, Nuclear Energy Division, General Electric Co., San Jose, Calif.

My name is Robert Lowenstein. I am Counsel to General Electric's Nuclear Energy Division, which has its worldwide headquarters at San Jose, California. I have had more than 20 years' experience in the regulatory programs affecting the nuclear energy industry, including service for five years as AEC's Director of Licensing and Regulation and as Assistant Director of Regulation. Before taking my present position in August, 1972, I was a partner in Lowenstein, Newman and Reis, a Washington law firm, which specialized in nuclear energy legal problems. In addition, I presently serve as Chairman of the Atomic Industrial Forum's Lawyers Committee and as a member of the Special Committee on Environmental Law of the American Bar Association. I am appearing before you today solely as counsel to General Electric's Nuclear Energy Division.

I should like to thank the subcommittee for this opportunity to submit this statement regarding reoganization of the federal government's energy efforts. General Electric supports separation of the Atomic Energy Commission's developmental and regulatory functions and urges the prompt enactment of legislation to create a Nuclear Energy Commission and an energy research and development agency.

We support establishment of an energy research and development agency because of the need to bring together the now fragmented programs and resources of many federal agencies. Establishment of an agency to administer energy research and development programs will make it possible for the federal government to coordinate its energy research and development programs and to apply its resources, including the unique capabilities of the AEC's National

Laboratories, more effectively to develop new sources of energy and new means for their utilization.

General Electric's original and still basic business lies in the generation, distribution, and use of electric energy, whatever fuel is used. We are confident that an energy research and development agency will facilitate those technological developments which are now so vitally necessary to maintain our society. We are confident that these developments can be accomplished and that they can provide the bridge to an unprecedented era of peace and prosperity in our country and throughout the world.

A second major objective of the proposed reorganization, to which I propose to direct the balance of my statement, is the establishment of a Nuclear Energy Commission. Proposals to place the AEC's regulatory functions in an agency separate from the Commission's operating and promotional programs have been made repeatedly over the years since 1955. There has been recurring concern that the combination of regulatory and promotional functions in the Atomic Energy Commission has weakened the credibility of the Commission and impaired public confidence in the adequacy of its regulatory programs.

I do not mean to suggest that the Commission's promotional responsibilities have resulted in any weakening of its safety requirements, or that the Commission ever failed to take appropriate action on any matter because of its promotional concerns. As one who spent many years deeply involved in administration of the AEC's regulatory program, I can affirm that the Commission has always regarded its nuclear safety responsibilities as its paramount and overriding concern. Nevertheless, the combination of regulatory and promotional functions has been a cause of impaired public confidence in the AEC for many years. Since public confidence is so vitally important to the administration of the Commission's programs and to utilization of nuclear energy, we believe that the Commission's regulatory responsibilities should be separated from its other functions and placed in a separate agency unless there are other compelling reasons why separation would not be in the public interest.

In earlier years when the Joint Committee on Atomic Energy considered the desirability of separating AEC's regulatory from its other responsibilities, there were persuasive reasons not to do so, including the relatively small size of the regulatory staff, the dependence of the regulatory staff on the AEC and its laboratories for technical assistance, and the fact that the nuclear power program was still in its infancy. Since that time, however, the regulatory staff has grown in size and competence, much safety research and development has been accomplished, and the nuclear safety standards program is well advanced. Operating experience with large nuclear power plants is accumulating at a rapid rate, and, with the encouragement of the Atomic Energy Commission, reactor designers, architect-engineering firms and others engaged in the industry are standardizing nuclear plants. There is no reason today to doubt that the regulatory staff is now of sufficient size and capability to provide the personnel and resources which would be needed by the Nuclear Energy Commission to carry out a healthy and vigorous regulatory program. I think, too, there can be little doubt that the Commissioners who constitute the heads of the Nuclear Energy Commission will be in a far better position to administer the AEC's regulatory responsibilities without the added responsibilities which would be vested in the energy research and development agency.

Separation of AEC's regulatory functions will serve an additional important objective. At present, the five Atomic Energy Commissioners have vast responsibilities of an extremely diverse nature; these responsibilities have made it impossible for the Commissioners to spend more than a minor portion of their time on regulatory matters. The addition of other energy development responsibilities to the agency's nuclear responsibilities would reduce still further the time available for the Commissioners to administer the regulatory program.

The Commission's regulatory program encompasses responsibility for the licensing and regulation of nuclear power plants, which are an increasingly significant source of electric energy. It also includes regulatory responsibiiity with respect to those related activities in the fuel cycle, which are indispensable to nuclear power. Moreover, the regulatory program has, during recent years, been broadened to include pervasive environmental and antitrust functions which must add significantly to the burdens already imposed on those charged with their administration. The burden of responsibility imposed by these regulatory functions on the heads of the regulatory agency will increase as the number of plants increases.

We believe that creation of a separate Nuclear Energy Commission to administer AEC's regulatory responsibilities is so important that even if the committee should decide to postpone establishment of an energy research and development agency as a separate organization, the Nuclear Energy Commission should be established now. Creation of the Nuclear Energy Commission would become still more urgent to the extent that the AEC is given additional development responsibilities prior to the creation of the new development agency.

We have two additional comments in connection with the provisions to establish a Nuclear Energy Commission:

1. Senate Bill 2744 would retain the concept of a five-member Commission. This, in our view, is highly desirable. A Commission of five members should be sufficient to assure that the heads of the agency have adequate time to become deeply and personally involved in the formulation and administration of nuclear regulatory programs, as well as the adjudication and review of cases. Moreover, five Commissioners can bring to the agency's deliberations a more diverse array of talent to oversee its diverse nuclear safety, environmental, and antitrust responsibilities.

2. We believe the committee should make plain its expectation that the Nuclear Energy Commission should discontinue the use of Appeals Boards. The use of AEC Appeals Boards has proven in our judgment to be a cumbersome, time-consuming, and unsatisfactory procedure for review of licensing board decisions. We believe that the questions involved in these decisions involve many novel and important policy questions which should be decided by the heads of the agency. A separate NEC with five Commissioners should be able to provide for review of licensing board decisions by some or all of the five Commissioners.

Statement of Pratt & Whitney Aircraft, Division of United Aircraft Corporation, Prepared for Committee on Government Operations, Subcommittee on Reorganization, Research, and International Organizations, Hon. Abraham Ribicoff, Chairman, December 11, 1973

(By Bruce N. Torell, Division President, East Hartford, Conn.)

ENERGY RESEARCH AND DEVELOPMENT

As a leading producer of aircraft powerplants and as a supplier of equipment for electric power generation, Pratt & Whitney Aircraft wishes to express support of Senate Bill S.2744. This bill proposes to form a new Energy Research and Development Administration (ERDA) for the purpose of consolidating the R&D efforts of the Country to meet our national objective of self-sufficiency in energy needs. It is clear that extensive R&D programs will be required as part of the solution of the energy problem and that the effectiveness of such programs can be greatly enhanced by creation of a central responsible authority that is properly organized, chartered, and integrated within an overall energy policy. S.2744 has given careful consideration to the problems of organization of ERDA, and the transition of various existing agencies to operation under the administration of ERDA. The use of existing contracting instruments and regulations with which related industrial sectors are already familiar presents a minimum of contractual difficulty, and should assist in a rapid transition with a minimum of disruption to important on-going programs.

The task to be undertaken by ERDA is recognized to be complex and urgent. An important aspect of this task is the selection of the particular set of R&D programs that are to be undertaken, i.e., the establishment of priorities and the subsequent allocation of R&D resources.

In order to select the proper course through the almost infinite range of possible technical solutions to our energy problems, ERDA must have a clear definition of goals and have a comprehensive understanding of how each R&D program will contribute to these goals. These goals are the ultimate large scale production of energy in needed forms and extensive use of efficient energy converting systems. We emphasize here "large scale production" and "extensive use" in recognition that research and development alone are not enough. The research and development will only be successful if the results separately or in combination with other economic incentives, bring about the desired changes in our energy production and use patterns on a major scale.

Therefore, we place great importance on the need for high level overall analysis and planning within ERDA to ensure that resources allocated to individual R&D programs have the highest probability of producing not only the desired

technology but technology that can and will be rapidly exploited by the energy industry. To be exploited, a new concept must show not only technical feasibility but must offer payback and profit that are sufficiently attractive to induce industry capital to take the next step. Any selection process that does not realistically assess all the steps from R&D to commercial acceptance runs the risk of investing in technical successes that may be economic failures.

These needs, then, speak for a strong planning function at the top level of ERDA with authority to allocate resources on the basis of its thorough evaluation of the role that individual energy concepts will play in the near term and long term energy picture.

The ERDA Bill properly places primary emphasis on R&D as a major part of the long term solution to the nation's energy needs. To complement this effort, we hope the Administrator will provide for analysis and encourage implementation of the technologies already available for the nation's near term requirements.

Further, we encourage close collaboration between ERDA and industry during R&D planning and execution phases. Close working relationships will be required to assure the timely utilization of the technology developed to meet national objectives.

Beyond our comments pertaining directly to the Bill, we would like to encourage the government to provide motivations for industry participation and independent investment to supplement the efforts of ERDA. Energy availability is a national need and the government should serve as a focal point in rallying all available talents and resources.

AREAS REQUIRING COOPERATIVE INDUSTRY-GOVERNMENT EMPHASIS

We anticipate that the National Administration will set the goals upon which ERDA will base its policy planning. In setting the National goals some means should be provided in the government for encouraging industry and public participation. As noted before, the successful attainment of our goal of energy self-sufficiency will require strong cooperation and mutual assistance between government and industry to offset or neutralize the large economic risks to an acceptable degree. Some of the areas where this kind of cooperation and assistance is vital are discussed below.

The most critical aspect of the energy crisis is, of course, the lack of an adequate supply of petroleum within the United States. However, this country is blessed with enormous coal deposits, enough to supply all of our energy needs for several hundred years, assuming continuing expansion of our economy at the present rate. In addition, we have vast quantities of oil shale which can be exploited. The utilization of these tremendous resources in an ecologically acceptable manner is vital to our economy as well as our security in the world. Techniques for shale oil recovery and for coal gasification and liquefaction must be developed together with means of removing objectionable pollutants from the products.

It appears to us that top priority must be placed upon the development of petroleum substitutes which can be used directly in existing transportation vehicles, aircraft, and other powered equipment. However, instability in the price and supply of the world's petroleum market introduces a high degree of economic risk in the investment in production facilities for extraction of shale oil or the production of liquid fuels from coal. These fuels cannot be produced profitably if the world price of petroleum should subsequently be depressed by political forces. It appears that government assistance to industry in this area will be needed to offset business risks and encourage the development of our coal and shale oil resources into sources of petroleum product substitutes.

One of the products most easily produced from coal is low heating value gas. This gas is a satisfactory fuel but is uneconomical to transmit, must be produced where it is used, and requires some special techniques for efficient utilization. Very large gas turbines, perhaps combined with waste heat recovery systems utilizing steam, offer an economic means of utilizing low heating value gas for electric energy generation on a time schedule consistent with the availability of this fuel. Cooperative government-industry programs are needed to develop an integrated gasification and energy conversion system required to utilize this important energy source.

The fuel cell is a space age development which offers the potential for more efficient conversion of the chemical energy from gasified coal or residual petroleum as well as conventional fuels to electricity in an ecologically acceptable way. It also appears to offer the potential for dispersion of electrical generating facilities in areas where the construction of very large facilities is impractical or undesirable. We think development of fuel cells for this application deserves more emphasis.

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The United States has abundant supplies of uranium and thorium within its boundaries. These materials provide the energy source for the generation of electricity from fission. It appears likely today that most of the nuclear electric generating stations to come on line through the end of this century will utilize enriched uranium as a fuel. Present enrichment facilities owned by the government are inadequate to provide our projected national requirements for enriched uranium by the early 1980's. Additional enrichment plants based on either the diffusion process utilized in the present government plants, or new processes such as the gas centrifuge, must be placed on stream beginning in the early 1980's. While the Administration is attempting to encourage private enterprise to provide this additional enrichment capability, the business risk of such an enormous venture is very great and perhaps unacceptable. It appears that strong industry-government cooperation in attention to this problem will be vital to reduce the business risks to an acceptable level and thus insure an adequate and timely supply of nuclear fuel. Furthermore, if we are to make the most effective use of the natural fissionable isotope U235 prior to the advent of the breeder reactor, we must place more emphasis on plutonium recycling and on the development and application of more efficient fuel cycles such as the high temperature gas-cooled reactor.

The continued development of our economy and quality of life as well as that of the rest of the world generates an ever-increasing requirement for energy. The principle sources for this energy appear in sequence to be fossil fuel and fission without breeding for a few hundred years at best, fission with breeding for several centuries, and ultimately fusion which promises an essentially unlimited supply of energy in terms of all conceivable human needs on this planet. The efficient use of fission fuels, uranium and thorium, require the development of breeder reactors. The development of the liquid metal fast breeder reactor is already a national goal with top priority funding. In view of the ultimate importance of the breeder reactor to the fission fuel economy, we believe alternative solutions to this problem, such as the gas cooled breeder reactor, should also be pursued with vigor.

The ultimate source of energy for mankind is fusion. The development of a system for the controlled application of the fusion process to the generation of electricity from deuterium is an immensely complex and expensive undertaking. Compared to the ultimate importance of this process, the present level of effort on this problem is minimal. In fact, the present effort is probably much too small to accomplish the eventual development of a practical fusion system for electrical generation. It would appear reasonable to accelerate the effort on fusion research and development with increased engineering emphasis on demonstration type programs, so that we can make measurable progress toward the absolutely essential ultimate goal of the utilization of this source of energy.

SANDIA LABORATORIES,
Albuquerque, N. Mex., December 3, 1973.

Hon. JOSEPH MONTOYA,
U.S. Senate, Washington, D.C.

DEAR JOE: During our recent discussion you suggested that I send you, at an appropriate time, my views on the organization of the government's energy program and the future role of the AEC laboratories. In view of Congress' current activities in this area, I am now taking this opportunity to summarize some of the considerations in which you have expressed an interest.

Much of the discussion in Congress and in the scientific community has centered about placing the responsibility for energy research and development (R&D) either with a new Energy Research and Development Administration (ERDA) or with the Department of Interior. There has also been discussion of the future role of the AEC weapons laboratories—within the Department of Defense, within a new Nuclear Energy Commission, or within ERDA. My comments in this letter address some of these alternatives, particularly as they effect the weapons laboratories.

First, let me summarize my views thusly:

1. All energy R&D programs should be centralized in one agency; ERDA being the best approach proposed to date.
2. Energy R&D should be the sole concern and charter of this agency; again, ERDA fills the bill.
3. This agency should be independent of existing governmental departments where its programs and budgets are in competition with other departmental activities.

4. AEC functions, minus regulation and licensing, should be taken over by this agency. The AEC laboratories, already a proven, successful, and ongoing national scientific complex, could immediately serve as a base from which to initiate an aggressive energy R&D effort. A special note—I would suggest that legislation concerning ERDA specifically mention that weapons R&D should also become a responsibility of ERDA.

Now I'll comment on these four points in more detail:

1. *Centralization of Energy R&D.*—Offhand, I cannot think of another national program that collectively offers the complexities, the challenges, the short and long range costs, the personal and economic effects on all people inside and outside our national borders, and the myriad of possible solutions to pursue, than does the energy R&D program. There will be billions of dollars; unknown thousands of researchers and other program employees; and academic institutions, private industry, and governmental organizations all involved ultimately in the definition, research, development, and solution of our energy problems. For these reasons, it is imperative that all current and future energy R&D programs—including fossil fuels, geothermal, solar and nuclear, among others—be placed under one roof. Our country has and will commit to energy R&D vast resources of dollars and technical manpower, but these resources are not unlimited. Intelligent and effective utilization and allocation of these resources among the many alternatives possible will require centralized decision making.

2. *Energy R&D—Sole Charter.*—With the complexities and costs involved in establishing and implementing a national energy R&D program, it is axiomatic that the administration and budgetary aspects of such a program must be the responsibility of extremely knowledgeable managers; further, that this responsibility be the object of their full-time energies. This is the way the AEC was set up and has been carried out for the past quarter of a century; the results, I feel, are ample justification for my opinion above. Consider the AEC's well-known efforts—weapons programs, support of university research in diverse areas, and nuclear energy.

3. *Independent Agency.*—My strong feelings on the necessity for and results of energy R&D being the charter of an independent agency again is based on the long history of program success and stability of an independent AEC. Another consideration—energy R&D program proposals and budgetary requests from an independent agency like ERDA, I suspect, would lend themselves to more objective analysis and evaluation by Congress and the Executive branch than were such proposals emanating from another governmental department. There energy R&D would have to compete for attention with other large programs. Further, an independent agency would be less subject to extraneous pressures or problems that it might encounter were it part of the Department of Interior or Department of Defense.

4. *AEC Labs Under ERDA as Energy R&D Base.*—The past accomplishments and the present and future capabilities of the AEC laboratories suggest that they will make a most valuable contribution to the energy R&D program. As an existing national R&D laboratory complex, they can well serve as a base from which to immediately launch aggressive programs in many key energy R&D areas.

a. The DOD Blue Ribbon Panel of 1970 which included Mr. William P. Clements, Jr., now Deputy Secretary of Defense, specifically mentioned the AEC Weapons Program and NASA Apollo Program as the two best examples of R&D management which DOD should study for their own programs.

b. I think it is important that the management philosophy of the AEC's Division of Military Application has allowed the weapons laboratories' management to plan programs which have resulted in rapid advances in technology. Under their philosophy, the AEC has provided level-of-effort rather than program-by-program funding to its laboratories. This has made it possible for the laboratory management to undertake research and advanced development programs formulated within the laboratories. This part of the innovative process is the area of greatest risk, i.e., where new ideas are tried out. High risk programs are a necessary part of the successful R&D.

c. The AEC laboratories have the respect of the scientific community and, as a consequence, have been able to attract top-notch talent. The relations of these laboratories with the academic community have been excellent and many cooperative efforts have been and are now being carried on. These unofficial incentives for employment with AEC-involved programs would be most helpful to an agency like ERDA.

d. New energy responsibilities will be particularly important to the AEC weapons laboratories in this era of decreasing defense funding. Energy responsi-

bilities can provide new challenges for the laboratories' staff. With broader responsibilities, it will also continue to be easy to attract top-notch talent.

I appreciate your asking for my comments on this subject; I hope they are helpful. I would be most pleased to discuss them further with you at your convenience.

Yours sincerely,

MORGAN SPARKS.

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, D.C., December 4, 1973.

HON. ABRAHAM RIBICOFF,
Chairman, Subcommittee on Reorganization, Research, and International Organizations, Committee on Government Operations, U.S. Senate, Washington, D.C

DEAR CHAIRMAN RIBICOFF: American Public Power Association, which represents some 1,400 local publicly-owned electric power systems in 48 States, Puerto Rico, the Virgin Islands, and Guam, wishes to offer for the consideration of your subcommittee the following comments on S. 2744, to reorganize and consolidate certain functions of the Federal government in an Energy Research and Development Administration and in a Nuclear Energy Commission:

1. APPA strongly supports efforts to accelerate and coordinate research and development so as to expand the nation's options in dealing with energy-related economic and environmental problems.

APPA itself has taken steps to help advance this goal. APPA set up its own APPA Research Program in 1968, was one of the original participants in the electric industry's Electric Research Council, joined with other utility ownership sectors to form and fund the Electric Power Research Institute, and is taking part in the Liquid Metal Fast Breeder Reactor plant demonstration project.

APPA has also endorsed legislative proposals aimed at broadening the Federal government's role in energy research and development. APPA has backed the objectives of S. 357, to create a Federal Power Research and Development Board, and S. 1283, to provide coordination and financial supplementation of Federal energy research and development and to demonstrate particular technologies. APPA support of the purposes of these measures is predicated on the belief that reliance on voluntary efforts and existing governmental programs is not an adequate answer to the need for energy research and development because (a) the very large volume of funds required will not be forthcoming and (b) the public policy direction demanded is not present.

2. The two principal steps which would be taken with enactment of S. 2744 are (a) to create a new Federal agency charged with exercising central responsibility for policy planning, coordination, support, and management of energy research and development and (b) to separate licensing and regulatory functions of the Atomic Energy Commission from its other activities. APPA has endorsed the principle involved in the first step in connection with other legislative proposals, and while the Association has no formal position on the second step, it is clear that separation of nuclear licensing and regulatory responsibilities from so-called "promotional" duties would decrease the potential for conflict of interests, thus enhancing public confidence in the integrity of the decision-making process involved in approval of nuclear power plants.

3. Advantages of the approach to Federal energy research and development contained in S. 2744 include creation of a Federal focal point of such work which will permit more systematic consideration of alternate courses of action, opportunity for more rational reviewing of funding of all energy related projects, coordination in carrying out programs, and easier identification of progress in specific fields. It is important to note, however, that while the plan contained in S. 2744 encompasses energy research and development activities in the AEC, Office of Coal Research, Bureau of Mines, Department of the Interior underground research program, National Science Foundation, and Environmental Protection Agency, it does not cover all of the energy-related and development work of all of those entities nor does it touch at all the work of others in the Federal government.

4. APPA would like to make these suggestions for changes in S. 2744:

a. Section 103(1) specifies that the functions of the Administrator shall include "exercising central responsibilities for policy planning, coordination, support, and management of research and development programs respecting all energy sources, including assessing the requirements for research and development of the various forms of energy sources, managing such programs, and disseminating information resulting therefrom . . ."

The ways in which we move in energy research and development are in part dependent on what our objectives are. Since resources of time and money are finite, it is necessary to make choices. There is an environmental maxim which says that "Everything is connected to everything else." It is becoming ever more apparent that this statement applies to energy as well. For this reason, we need in the Executive Branch a high level agency capable of formulating a comprehensive and coherent energy policy and of coordinating its implementation through "line" agencies and departments. A move in this direction is Senate passage of S. 70, to create a statutory three-member Council on Energy Policy. APPA urges that in your subcommittee's deliberations on S. 2744, you consider incorporating the proposal embodied in S. 70 because it has a direct bearing on the functions of ERDA.

The establishment of priorities for energy research and development must flow from broad energy policy decisions involving such matters as environmental protection, economic growth, population expansion and distribution, balance of payments, and foreign relations. These questions must be decided in a fashion which insures full public discussion and broad political support. Research and development efforts should be aimed at supporting the resulting decisions. Addition of the concepts of S. 70 to S. 2744 would aid in achieving this objective.

b. One of the by-products of the energy research and development work carried out or financed by ERDA will be fuel and/or energy. Large scale demonstration facilities may produce significant quantities. APPA urges that S. 2744 be amended to include a preference clause which provides that in the disposal of such fuel and energy as represents the Federal interest, preference shall be given to Federal agencies, public bodies, and cooperatives. An anti-monopoly feature of this type is found in Federal statutes dealing with licensing of hydroelectric projects, marketing of Federal water power, and certain projects of the AEC, and other laws. Its inclusion in S. 2744 would be appropriate and desirable in the public interest. In the same vein, the bill should include language giving Federal, State, and local government first rights to acquisition of property surplus to ERDA's needs.

c. By achieving a dominant grasp of new technology, an energy company may place itself in a position to engage in anti-competitive activities contrary to the public interest. ERDA's activities should not become a possible means for enhancement of monopolistic control. Ability to deny know-how to others can constitute an important weapon in killing competition. To discourage this possibility, it would be useful to incorporate in S. 2744 the requirement that major agreements concluded with non-Federal participants be reviewed by the Department of Justice in advance of execution to determine that activities under the arrangement would not create or maintain a situation inconsistent with the antitrust laws.

d. Because the activities of ERDA have a close relationship to ongoing energy research and development work by other entities in the electric utility field, it would seem useful to provide for a means of communication and coordination in S. 2744. APPA suggests that the bill be modified to provide explicitly for a permanent liaison committee composed of utility personnel representing all ownership segments of the industry, thus insuring availability of an important body of expertise for consulation and aiding elimination of undesirable duplication of effort.

e. S. 2744 does not deal with the substance of energy research and development projects. If S. 2744 is enacted, subsequent supplemental decisions must be made as to what research and development tasks will be tackled and in what order of priority.

Attention needs to be devoted to dealing with institutional inhibitions which may represent obstacles to implementation of the product of energy research and development, including such proposals as the modular integrated utility system (MIUS), the fuel cell, and solar energy.

The government, for instance, should consider funding for the creation and building of a model city that would make the best utilization of energy, and would serve as a laboratory for testing new concepts in energy conservation.

At the present time, the Disneyworld complex in Florida represents the only sizeable effort to marry advanced techniques of sewage and waste disposal, heating, cooling, hot and cold water supply, transportation, and electric service into a single complex.

APPA is aware of the work being done by several government agencies on the MIUS, which is a combined processing plant that generates electricity; uses residual and recycled energy for heating, air conditioning and hot water; treats water; and processes solid and liquid wastes.

APPA applauds these efforts, and hopes they will be accelerated. Although MIUS could be incorporated in a model city such as we envision, the concept of developing a model city that would have energy conservation as its primary focus would extend beyond MIUS.

A Federal program aimed at demonstrating energy conservation techniques in residences, commercial buildings, industrial processes and urban planning would serve as an excellent living laboratory for utilities, developers and manufacturers. It would not be necessary for the Federal government to provide all of the funds for such a model; private enterprise could participate in a meaningful way, and the model itself could provide a tremendous stimulus to private enterprise to seek further refinements and improvements upon the innovations developed by the model.

One Federal agency which might be considered for the role of building such a model city would be the Tennessee Valley Authority. At an earlier stage in history TVA established a model for regional water resources development that has served as a model for many nations. As a pioneer in many areas of energy resources development and utilization TVA would be an appropriate agency to carry on this new experiment. It goes without saying, of course, that environmental considerations also should be a prime objective in the design of such a model city.

Furthermore, reassessment of old solutions is needed to determine their applicability to the future. For example, the U. S. has developed only one-third of its total potential hydroelectric potential, even though this resource permits substantial savings in terms of fuel conservation. Hydroelectric energy generated annually is currently the power supply equivalent of 354 million barrels of oil, 2,233 billion cubic feet of natural gas or 93 million tons of coal.

I would appreciate it if these views could be incorporated in the hearing record on S. 2744.

Sincerely,

LARRY HOBART,
Assistant General Manager.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS,
Washington, D.C., December 4, 1973.

Hon. ABRAHAM RIBICOFF,
Chairman, Subcommittee on Reorganization, Research and International Organizations Committee on Government Operations, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: The Institute of Electrical and Electronics Engineers and the National Society of Professional Engineers, representing an aggregate of over 200.000 individual engineers, respectfully submit the attached Statement in support of S. 2744, a bill to reorganize and consolidate Federal energy R&D functions.

Also submitted herewith is a Statement on S. 2744 subscribed to by the presidents of the American Institute of Aeronautics and Astronautics, American Institute of Chemical Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, Institute of Electrical and Electronics Engineers, and National Society of Professional Engineers. The membership of these societies includes approximately 480,000 individual engineers and scientists.

We request that these Statements be considered during the course of Committee deliberations on the measure, and that they be incorporated in the official transcript of current hearings.

Very truly yours,

PAUL H. ROBBINS, P.E.,
Executive Director.

Enclosures.

STATEMENT OF
AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS;
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS;
AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS;
AMERICAN SOCIETY OF CIVIL ENGINEERS;
AMERICAN SOCIETY OF MECHANICAL ENGINEERS;
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS; AND
NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

The above listed engineering societies appreciate the opportunity to submit their views concerning S. 2744. The membership of these societies includes approxi-

mately 480,000 engineers and scientists, many of whom are directly involved in the production, transformation, distribution and use of energy in industry and commerce, and all of whom are consumers of energy as citizens of the United States.

We are encouraged that the general public, the Congress, and the Administration are becoming aware of the real magnitude and the numerous debilitating consequences of the growing shortages of primary energy in this country. Self sufficiency in energy production, a National goal just recently proclaimed, involves large scale increases in research and development related to energy as well as a vast improvement in the overall National strategy and management of that effort. A general misunderstanding exists, however, as to the great length of time and the enormous magnitude of effort which will be required for the United States to become self sufficient in the production of environmentally clean energy.

Research and development, including large scale pilot plant and process demonstration, will be required in all phases of energy recovery, conversion, processing, distribution and utilization. Governmental attention must be devoted to areas of research and development which have heretofore been neglected. All this essential effort could come to litle or naught, however, unless the research activity were effectively coordinated and the development activity effectively and efficiently managed.

The solutions to difficult problems depend upon men and not organizations, but faulty or inadequate organization can frustrate and nullify the efforts of the best of men. We share a concern in this connection that Section 106(a) of S. 2744 does not reference the voluntarily developed consensus standards that have been consistently referenced by state and Federal regulatory bodies over the years. We offer for your consideration the following wording which could be added to Section 106(a):

"The Administrator is authorized to reference American National Standards as appropriate in Administrative Regulations and Guides."

S. 2744 recognizes the need for a major step in the improvement of energy organization. Much more will be required if research and development results are to be translated into National energy production and management programs to make us self sufficient in 20 years (even by the year 2000), but a National organization for energy research and development is a necessary first step because the products of research, development and demonstrations are going to be necessary to all future actions.

We strongly recommend proceeding expeditiously.

HOLT ASHLEY,
President, American Institute of Aeronautics and Astronautics.
THEODORE WEAVER,
President, American Institute of Chemical Engineers.
JAMES B. AUSTIN,
President, American Institute of Mining, Metallurgical and Petroleum Engineers.
CHARLES W. YODER,
President, American Society of Civil Engineers.
DANIEL C. DRUCKER,
President, American Society of Mechanical Engineers.
HAROLD CHESTNUT,
President, Institute of Electrical and Electronics Engineers.
ROBERT L. REITINGER,
President, National Society of Professional Engineers.

STATEMENT OF THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS TO THE SUBCOMMITTEE ON REORGANIZATION, RESEARCH, AND INTERNATIONAL ORGANIZATIONS, COMMITTEE ON GOVERNMENT OPERATIONS, U.S. SENATE, ON S. 2744, DECEMBER 4, 1973

The Institute of Electrical and Electronics Engineers and the National Society of Professional Engineers appreciate the opportunity to submit their views concerning S. 2744. The membership of these societies includes over 200,000 engineers, many of whom are directly involved in the production, transformation, distribution and use of energy in industry and commerce and all of whom are consumers of energy.

We are encouraged that the general public, the Congress and the Administration are becoming aware of the real magnitude and the numerous debilitating

consequences of the growing shortages of primary energy in this country. Self sufficiency in energy production, a national goal just recently established, however, involves large scale increases in research and development related to energy as well as a vast improvement in the overall national strategy and management of that effort. While public pronouncements containing optimistic self-sufficiency forecasts in terms of time and effort might have some psychological value, engineers realize that solutions of the problems are complicated and difficult.

Research and development, including large scale pilot plant and process demonstrations, will be required in all phases of energy recovery, conversion, processing, distribution and utilization. Areas of research and development which heretofore have been of little or secondary interest to industry must be expanded. These include nuclear fusion, solar, and geothermal sources of energy, as well as conservation and improved efficiency in energy conversion, distribution, and use.

Governmental proposals for increased funding of energy research generally and attention to the neglected areas are encouraging, but can not be implemented unless effectively and efficiently managed.

The Chairman of the Senate Interior and Insular Affairs Committee has stated, in his memorandum transmitting the staff analysis "Federal Energy Organization" [Serial No. 93–6 (92–11)] March 6, 1973, prepared in response to Senate Resolution 45 of the 92d Congress:

"The well-publicized deficiencies of Federal organization in the energy field have become increasingly apparent in the course of the National Fuels and Energy Policy Study authorized by the 92d Congress. Whether the subject is oil import policy, energy resource management or research and development programs, the lack of adequate authority and proper coordination is all too clear. And while no one suggests that better organization by itself will solve our energy problems, there appears to be general agreement that a revamped and strengthened energy organization is a necessary event to more rational energy policies."

The Analysis states: "Throughout the hearings and studies, it has been apparent that there is a significant organizational aspect to energy problems. The existing organization has contributed to current and emerging problems in at least three respects:

(1) it has failed to anticipate emerging energy problems, such as diminishing fuel reserves and environmental confrontations, and to initiate timely corrective action to forestall crises;

(2) it has failed to react adequately to mitigate those crises which have, in fact, occurred, such as increasing fuel shortages and loss of electric power system reliability, and

(3) it does not appear to have the initiative and sufficient reliable and credible information to develop and support the policy decisions which must now be made."

The societies clearly recognize the solutions to tough problems depend upon men and not organizations, but faulty or inadequate organization can, nevertheless, often frustrate and nullify the efforts of the best of men.

The United States has on occasions in the last few decades demonstrated it's capabilities to combine men and organizations to achieve great things. What this country really needs, in the view of it's technologists, is firm commitment to a national purpose structured in much the same way and with promise of the same success as were the programs what put men on the moon through NASA's efforts; provided electricity to rural areas through the creation of TVA; produced the Navy FBM weapons system through the Special Project Office; unlocked the secrets of the atom for defense needs through establishment of the AEC.

Once we establish an adequate research and development organization, we can proceed to install the visionary leadership and administrative talent needed to accomplish this truly herculean task.

S. 2744 provides a major step in improvement of energy organization. Further steps will be required to translate research and development results into national energy production and management programs which can make us self sufficient. But rationalizing the organization for energy research and development is an essential immediate step in the implementation of this activity if we are to reach energy self sufficiency even by the year 2000.

The engineering societies wholeheartedly support S. 2744.

We recognize that there continues to exist a serious concern with the placement of weapons research and development responsibility in the proposed Energy Research and Development Agency. We believe, however, that the inevitable delays which would develop as the Congress attempts to resolve that problem at this time could have a most serious effect delaying critically needed energy research and development programs.

We strongly recommend proceeding expeditiously with H.R. 11510. While noting that the Energy Reorganization Act of 1973 is intended "to bring together and direct Federal activities relating to research and development on various sources of energy" we would in closing point out that, important as S. 2744 is, it is but a single factor in the extraordinarily long list of vital measures that the Congress and the Administration must address without a single days further delay if the United States is to survive, socially, economically and militarily as a free nation.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Pasadena, Calif., December 5, 1973.

Hon. ABRAHAM RIBICOFF,
U.S. Senate,
Washington, D.C.,

DEAR SENATOR RIBICOFF: Attached is a memorandum which may be of interest to you and your committee during your deliberation on the establishment of an energy research and development agency. The memorandum outlines the efforts of an Ad Hoc Committee on National Energy organized by me at the California Institute of Technology. I hope to be in touch with you further on this matter in the near future.

Sincerely,

HARRISON H. SCHMITT.

MEMORANDUM FOR THE RECORD

A meeting of an Ad Hoc Committee on National Energy has been organized for early December under my auspices as a Fairchild Distinguished Scholar at the California Institute of Technology. The Committee is composed of several of the leading fuel and economic geologists in the country. The meeting was set up with the hope that an independent group of experts might make suggestions on national energy alternatives which could stave off a potential national emergency related to energy resources. We conceived of this meeting one day *prior* to the start of the recent Arab-Israeli confrontations.

Much to our dismay, events have passed us by and that emergency is now upon us.

Therefore, I am taking this method of setting before you a summary of the issues we still intend to address. I hope that you will also give some thought to these issues as outlined here, some of which I believe represent a new point of view. Following our meeting, we hope to be able to formally transmit our conclusions to you in order to assist in your considerations of legislation that will see us through these unprecedented times.

SETTING

The United States is faced with serious energy problems which jeopardize the national well-being. It is clear that a major, goal-oriented program of research and development is necessary to create a long-term alternative to fossil fuels as an energy source; a solution that must be available within the next 15 to 20 years. However, in the interim, a massive shortage of fossil fuels could bring on a world-wide financial collapse or depression. At worst, the prevention of such a collapse is presently at the mercy and control of the Arab nations. At best, the restriction of energy consumption attendant to complete reliance on our own present resources would bring about an intolerable unemployment level and economic stagnation, not to mention personal suffering, until adjustments in energy relationships can be made.

Recognizing on the one hand that the current energy crisis in the short term is man-made and requires a political solution, on the other hand there are certain fundamental *geologic* factors that must be ascertained. These factors must be the framework on which the Administration and the Congress base their political decisions. The purpose of organizing this Ad Hoc Committee on National Energy is to ascertain and establish this framework.

We believe that this geologic framework for political decisions can be established by answering some fundamental geologic questions, both in basic geology and in economic geology. These questions, when answered, should provide the basis for further action in this emergency.

GEOLOGY

Various geologic sources, principally the U.S. Geological Survey and the Natural Gas Supply Committee, have indicated an ultimate potential oil and gas reserve in the territorial United States of 400 billion barrels of oil and 1,200 trillion cubic feet of gas. These numbers can be misleading, as they ignore deliverability which at its potential maximum is only about 10 million barrels per day with respect to oil.

Questions

Is it geologically possible to become nationally self-sufficient in oil and gas production within the territorial United States, that is, can we achieve a necessary goal of 20 million barrels of oil per day by 1980 and 26 million barrels per day by 1985?

If the answer to the above question is "yes," how long will it take, in theory, to arrive at this point of self-sufficiency or at least to the point where the proven existance of self-sufficiency can begin to influence the world market place an world diplomatic councils.

To answer these questions, it is necessary to examine h w many major new oil and gas provinces we need and whether they may be geologically available. The prevailing intuitive opinion is that they are available; however, a stronger basis for action is needed. Further, we should examine how many giant and super-giant fields might fill our needs and whether we have reasonable hunting grounds for such fields, particularly in off-shore areas. For example, the giant Prudhoe Bay, Alaska, field has about a 10 billion barrel reserve and is capable of providing about 2 million barrels a day when in full production.

ECONOMICS

Questions

If we can become self-sufficient in oil and gas, what level and rate of expenditure is required? For instance, Chase Manhattan Bank and others have suggested that we require an increase in domestic exploratory wells from 14,000 to 55,000 a year which would require a change in annual expenditures from $7 billion to $30 billion. Where do such monies come from? How would such an effort in exploration and eventual production effect our national supplies and priorities with respect to other resources, such as steel, which is already in short supply?

If we *cannot* become self-sufficient in oil and gas, what level of attainment is realistically possible? At this realistic level, what is required as investments in other sources of energy, such as coal?

TECHNOLOGY

Questions

If no answers are presently possible to the above questions on geology and economics, what is the level of research and study expenditure to find the answers? Should we in this regard immediately finance a national oil and gas inventory comparable to the existing coal inventory performed by the U.S. Geological Survey?

Is the technology available for an oil and gas inventory in presently unexplored areas, both on-shore and off-shore? For example, do the new techniques in enhancing seismic signals so that the direct sensing of oil is possible offer a viable exploration tool?

If the technology is available, what is required in time, effort and money to fully explore the unexplored on-shore and off-shore regions of the United States and Alaska so as to delineate giant and super-giant fields? Similarly, what is required in test holes to establish geologic and production control of any discovered fields?

If the technology for this scale of exploration is not available, should we attempt to create it? What would such a research and development effort cost and how long would it take to bear fruit?

MANAGEMENT

Questions

What combinations of governmental, industrial and scientific management structures are required to accomplish those tasks represented by the answers to the above questions? For example, can the solution to this emergency be best accomplished by the creation of a governmental management structure with

contractual agreements with industry or should incentives be created which would result in industrial initiative such as was used in our search for uranium during World War II? As a case in point, Australia has moved from a status of having no domestic supply of oil and gas to self-sufficiency in the last decade through the use of special incentives.

Recognizing that environmental trade-offs must be made in certain cases, how do we compromise the present emergency and future needs with our long-term desire to preserve and enhance our environment?

SCHEDULE

Questions

Assuming we can become temporarily self-sufficient in fossil fuel energy within some politically tolerable time frame, how many years do we have before an alternative energy source *must* be available?

In establishing this schedule for long-term research and development, how much weight do we give to the preservation of fossil fuel resources for the needs of future generations? History will be very unforgiving if some significant weight is not given to this consideration.

SUMMARY

We are presently a nation in search of new options in our efforts to overcome a very serious emergency in our present and future supplies of energy. This emergency is having profound effects on our domestic and foreign well-being. By examination of the questions posed above, it is highly probable that some of those new options will become apparent. As soon as we as a nation have demonstrated self-sufficiency in our immediate needs for energy and have undertaken a clear and irrevocable commitment to a future alternative to fossil fuels as an energy source, we will have eliminated many of the foreign and domestic threats that currently beset us. At the very least, we will have created bargaining positions that would otherwise be unavailable.

HARRISON H. SCHMITT.

BABCOCK & WILCOX,
Washington, D.C., December 5, 1973.

Hon. ABRAHAM RIBICOFF,
U.S. Senate,
Washington, D.C.

DEAR SENATOR RIBICOFF: I thought you might be interested in the Babcock & Wilcox Company's views on H.R. 11510 "The Energy Research and Development Reorganization Bill of 1973," which is presently before the House Committee on Government Reorganization.

Sincerely,

MICHAEL T. KELLEY,
Assistant Manager.

Enclosure.

BABCOCK & WILCOX,
New York, N.Y., November 27, 1973

Hon. CHET HOLIFIELD,
U.S. House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN HOLIFIELD: I am pleased to have the opportunity to reply to your request for comments on H.R. 11510.

There is no question that our country needs a basic policy on energy that gives emphasis to energy-related research and development. The efficiency of energy converison must be addressed. The improvement in efficiency of electrical equipment, including the generation and transmission of electrical energy, is one area to which R&D effort shuold be specially directed.

While the more effective use of present energy sources is clearly called for, we belive R&D effort should be applied to new sources. This includes a stepped-up program for the construction of coal gasification plants and the expansion of R&D for oil shale, geothermal and solar energy. We believe that Senator Jackson's long-range proposal of $20 billion over a ten-year period for energy R&D is much more realistic than the Administration's proposal of $10 million, and the fair allocation of R&D monies to nuclear, fossil and advanced energy systems within the energy R&D agency is also clearly called for.

We note that the bill seeks to bring about part of what was originally proposed in H.R. 9090, an Energy Research and Development Administration and a sepa-

rate Nuclear Energy Commission. We are in favor of this approach and strongly recommend the immediate passage by the Congress of H.R. 11510, with the following reservations:

The creation of a Nuclear Energy Commission to handle regulatory safety research, environmental and waste progams and material safeguard programs leaves some questions in our minds. As we enter an era in which there will be less competition between power sources as there will be careful planning, it is not clear why two key agencies are needed. Perhaps, an expansion of the Federal Power Commission with the addition of some existing AEC Commissioners would be more effective in overseeing the entire power regulatory function. In the licensing process for nuclear power plants, any move which would improve the time required while maintaining necessary safety factors is desperately needed.

We note that the energy R&D administration which would also be made up of part of the current AEC will apparently assume the contracting systems for naval nuclear fuels that is now administered by the AEC. We believe this raises many questions concerning the posible effects on contract terms, approval cycles, levels of staffing and funding, etc. Also, what will be the role of the Director of Naval Reactors in ERDA?

Finally, as you note, a joint government-industry effort in the overall energy areas is very clearly called for. It is needed to avoid developing a national energy policy which would create goals that are not in concert with the well-being of the nation as a whole. Because of this and in view of the continually changing technology, it would appear strongly advisible to involve knowledgeable public groups as responsible representatives to participate in the development of such a policy.

Sincerely,

George G. Zipf,
Chairman and President.

American Petroleum Institute,
Washington, D.C., December 7, 1973.

Hon. Abraham Ribicoff,
Chairman, Subcommittee on Reorganization, Research, and International Organizations, Washington, D.C.

Dear Mr. Chairman: We are submitting for the record the attached statement on S. 2744, "The Energy Reorganization Act of 1973."

We hope that these comments will be useful to the Committee in its deliberations on this important matter.

Sincerely,

Frank N. Ikard.

Attachment.

Statement of American Petroleum Institute

The American Petroleum Institute welcomes the opportunity extended by the Subcommittee on Reorganization, Research and International Organizations of the Senate Committee on Government Operations of the present its views on proposal to establish an Energy Research and Development Administration.

The goal of increasing domestic energy supplies has the wholehearted support of the petroleum industry. Over a period of years, this industry has warned of the dangers of excessive reliance upon insecure foreign sources for the energy we must have to heat our homes, run our factories, and operate cars, trucks, buses and aircraft. Recent events in the Middle East expose the dangers of overdependence on potentially unreliable sources for any significant portion of our energy supply.

We must now take aggressive action to shore up our nation's energy base by developing secure domestic energy supplies, including supplies of both conventional and non-conventional fuels. This cannot be done overnight. It will take time. But unless our nation is to stagnate, unless we want to risk rising unemployment and spreading poverty, we must start now down the road to a greater degree of energy self-sufficiency. This requires that we develop all of our domestic fuels—conventional. fossil fuels, nuclear energy, oil an gas from coal, oil from shale and tar sands, geothermal steam, solar power, and other potential energy sources. We no longer have the luxury of concentrating our efforts on selected fuels while neglecting others.

An accelerated technological development program is an essential element of any program designed to rebuild our nation's domestic energy base. But to accompany this effort, policies must be developed to clearly define research objectives; to provide for continuing diversity in research, including balance between projects with short-term and longer-term impacts; to foster development of parallel technological options to insure a wide choice of alternatives; to use the potential of patent rights to provide incentives both for innovation in the R&D area and to justify the risks of commercial investment; and to dovetail the efforts of private industry and government so as to avoid unnecessary duplication and take advantage of the particular capabilities of both sectors.

The API endorses the proposed Energy R&D Administration as a means to develop and implement those policies by bringing together central responsibility for policy planning, coordination, support, and management of all Federally funded programs related to energy R&D.

The petroleum industry has directed increasing efforts to new sources of energy to meet the long-term needs of the nation, but its major programs remain focused upon finding and developing supplies of oil and gas from conventional sources. We believe this emphasis is correct. We will need every barrel of oil and every cubic foot of natural gas we can get to meet our energy needs over the next decade or more.

Among the examples of research of this type are efforts to improve oil recovery efficiency, including flooding with chemical solutions; to release natural gas, now locked up in tight reservoirs, by various fracturing techniques; to develop oil and gas production capability in deep water; to improve seismic methods and exploration techniques; and to convert crude oil more efficiently to useful products. Research projects such as these offer the quickest route to increasing our energy supplies in the near term.

Government, for its part, should direct its efforts more to nonconventional fuels and long-range R&D. Where the time span to commercial feasibility is so uncertain or so far in the future that it is difficult or impossible to attract necessary funding from the private sector, government support can supplement private efforts and accelerate technological development. Sound and well-balanced R&D programs can sharply reduce the time it takes to go from the laboratory through the demonstration stage, and thus speed the day when these new energy sources can be made available to consumers.

Thus, it is logical for government efforts to focus more on projects with longer time frames, and where private funding is unavailable or inadequate, while focusing private efforts on projects where technology is closer at hand and capital investment can be attracted to bring the energy source to commercial fruition.

Many projects will fall in between these two poles, and a different mix of government and industry funding will be required in each case. For example, the economic development of deep oil shale deposits may require in-situ processes, and much R&D remains to be done. Heavy government funding of joint government-industry R&D projects to develop methods and to demonstrate feasibility would be appropriate. On the other hand, oil from shallow mined oil shale is further along, and much of this work has been done by consortia of oil companies. Research and pilot plant development work have been completed, and the next step is to demonstrate technical and economic feasibility. Private capital is probably available for this demonstration and subsequent commercialization if appropriate oil shale leasing policies are adopted. We are pleased to note that a prototype leasing program has been announced this week. To achieve a balanced R&D program, it is apparent that shallow mined oil shale development can be funded primarily by private industry, while deep oil shale development would be speeded by increased government funding.

There is a clear and pressing need for a continuing organization which can recommend federal funding levels and their allocation in accordance with national energy priorities, and consistent with emerging national energy policies. There are probably a number of ways in which this need can be filled.

We believe the proposed Energy Research and Development Administration is one way in which this objective can be achieved. We believe that passage of this legislation would be an important step toward a strengthened and effective government R&D program.

To begin with, for an agency to effectively carry out programs for the optimal development of all domestic energy sources, it must be given maximum flexibility. To impose requirements that it spend a certain amount of money for oil shale, or some other fixed amount for coal liquefaction or solar energy, would place the

agency in a straight-jacket. It would be unable to accelerate efforts in areas which looked increasingly promising, or to reduce efforts in areas where technological or environmental problems clouded the outlook for commercial development. Optimum development of a given technology requires that the program and organizational structure be established specifically to fit the project. The Energy Research and Development Administration should have full flexibility to accomplish this. We are pleased to note that the bill provides the proposed agency with the flexibility needed to carry out its responsibilities.

As the energy crisis has deepened, the oil industry has been increasingly concerned over the failure of government agencies with important energy responsibilities to utilize the expertise available in our industry, in part because antitrust and conflict of interest laws stand in the way. This contrasts sharply with the situation during World War II, when hundreds of industry people were involved in all government agencies dealing with the problems of curbing domestic energy consumption and insuring adequate fuel for our Armed Forces. These people rendered distinguished service to their nation. In the case of the proposed Energy Research and Development Administration, it is important that individuals with strong backgrounds in fossil fuels be asked to accept important staff positions in the proposed new agencies, and that close liaison be maintained with both private industry and leading scientists in our universities through extensive use of advisory committees. If the new agency is to be staffed mainly by transferring people with background in nuclear energy R&D, and little effort is made to take advantage of the knowledge and skills available in other energy industries, the development of a well rounded and effective research and development program would be severely handicapped. With all respect for the sincerity, dedication and intelligence of many in government working on the energy problem, there is a crying need for experienced industry people in the government in both operational and advisory positions.

We have some questions about the desirability of including military R&D in the proposed new agency. We fully recognize the need for a strong and continuing military R&D program. However, there are few similarities between military and civilian R&D programs. In energy R&D, the problem is not only to develop technology but to reduce costs to make new fuels competitive with conventional fuels. Competitive costs are not a major consideration in military R&D. The objective of energy R&D will be to make newly-developed technology available freely and as quickly as possible, while military R&D must operate under maximum security and it is unlikely that even programs with commercial application could be made available without long delays to obtain security clearance.

We are concerned that military requirements might adversely affect the funding of important energy R&D programs unless these two different functions are completely separated.

Another of our concerns is that, while full consideration may be given in the development of an R&D program to the physical environment—air, water and land use—insufficient attention will be paid to the development of a sound economic environment. This is essential to assure the commitment of the massive private resources needed to bring new supplies to the consumer after the development of technology.

An important aspect of this economic environment is the area of proprietary rights. The protection of these rights by patents has traditionally been the incentive for technological innovation by industry. When patents related to Federally assisted development of technology are held by government and are freely available without royalty, experience has shown that utilization by the private sector often languishes. We concur with the patent provisions of the bill which recognize this problem by making it possible for industry to retain proprietary patent rights on a case-to-case basis. If we are to have government-industry partnership in the R&D funding and demonstration of new energy sources, there should also be partnership in sharing the rewards of success.

Another area which must be given attention if we are to have an effective energy R&D program is funding. It will take five to ten years for most R&D programs to achieve meaningful results. Such programs will require long-term commitments by energy companies. These commitments must be matched by long-term government contract authorizations rather than by annual appropriations subject to interruption or wide fluctuation.

Our present technological strength stems from the diversity of specialized knowledge and aggressiveness of personnel employed in our research organization.

In some industries, the U.S. no longer enjoys the world leadership that it enjoyed in the past. This is not true in the oil industry. U.S. technology in exploration, onshore and offshore drilling and production, and every other phase of petroleum operations is second to none. It is largely U.S. technology and equipment which is developing the North Sea, and which is gradually increasing the self-sufficiency of Western European nations. U.S. technology is employed throughout the Middle East, in Africa, in Indonesia, and throughout the Pacific Basin.

Federal R&D efforts should be designed to increase efforts to develop energy technology, including new energy sources, by building upon this strong and diverse technological base.

We believe this bill can contribute to this objective.

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